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NOVEMBER 1954

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A Journal for All Science and Mathematics Teachers

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School Science and Mathematics

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SCHOOL SCIENCE AND MATHEMATICS

VOL. LIV NOVEMBER, 1954 WHOLE NO. 478

FINAL NOTICE

Do you realize that it is now November and that the Annual Meeting of Central Association of Science and Mathematics Teachers is scheduled for November 26 and 27?

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H. VERNON PRICE, *President*

TECHNICAL MATHEMATICS FOR GRADES 9, 10, AND 11

MYRON F. ROSSKOPF
Teachers College, Columbia University, New York City

There are at least two points that deserve to be underscored again and again when the mathematics program of the senior high school comes up for discussion. (1) A society based on scientific achievements needs technicians to man the results of applications of science. (2) There exists the problem of the small high school with one or two mathematics teachers.

RECOGNITION OF THE PROBLEM

At the present time and in the predictable future there is a great need for a large number of men and women with all levels of training in mathematics. The job opportunities for a person with training in mathematics have mushroomed since World War II. Each year there are many vacancies in civil service, industry, and universities and colleges. The supply of mathematicians, physicists, chemists, and engineers falls far short of satisfying the demands. All of the persons in these job categories need large amounts of mathematics in order to complete their training.

Until the current shortage of mathematically trained persons, it was customary for an engineer in industry to do many tasks that could have been done as well by a person with less training. How is this known? Industries that employ large numbers of engineers have made job analyses. These job analyses reveal that some of the duties of their engineers could be performed as well by a man or woman with three or more years of high school mathematics and others by a college graduate with a major in mathematics. Thus, an engineer would be freed to devote his full time to the work for which he had been trained.

In 1952, 55% of the public high schools in the United States had an enrollment of from 10 to 200 students. A recent study[1] indicates that in 40 percent of public high schools of this size there are two or more regular teachers who devote part time to mathematics. A reasonable implication is that these small high schools cannot employ more than one well-trained teacher of mathematics. This means that one teacher is responsible for teaching all the advanced mathematics in the high school. Such a teacher would find it almost impossible to carry on a two track program in mathematics. He must

[1] Kenneth E. Brown, *Mathematics in Public High Schools*, p. 39. United States Department of Health, Education, and Welfare, Bulletin 1953, No. 5. Washington: Government Printing Office, 1953.

cast about for some sort of compromise program so that the needs of everyone are satisfied as nearly as possible.

Will such a program result in depriving a number of students who want technical mathematics of the opportunity of electing it? This does not seem a reasonable implication. A public high school is responsible for satisfying the needs of these students as well as those who are not so capable in mathematics.

Another matter that must be mentioned is the teaching of arithmetic in elementary schools. The program of arithmetic teaching in grades 1–6 is such that students come to junior high school with a better than even chance they will have learned arithmetic processes through a method of teaching designed to develop meaning for a process and understanding of the process. If you have looked at series of textbooks for grades 3–8 that have been published in the last half dozen years, you will have noticed that such a program of teaching places greater responsibility than heretofore on seventh and eighth grade teachers for teaching arithmetic.

Since more class periods must be spent on the teaching of arithmetic in the seventh and eighth grades, there will not be as much time available for instruction in informal geometry or elementary algebraic concepts. An implication of this situtation is that students in such a program will complete the eighth grade with hardly a speaking acquaintance with geometry and fundamental concepts of algebra like symbols, formulas, linear equations, and possibly directed numbers.

Formulation of the Problem

The foregoing discussion places certain conditions on the technical mathematics program for grades 9, 10, and 11. In the first place, the large percentage of small high schools in the United States imposes the condition that a two track program be avoided. This means that the planning must take into consideration the mathematical needs of almost all ninth graders; that is, students whose abilities in mathematics range from low to high.

In the second place, the new responsibility for teaching arithmetic that has been forced on seventh and eighth grade mathematics teachers by elementary school programs in arithmetic implies that the mathematics courses in those upper grades must be relieved from the pressure of crowdedness. This means that certain topics formerly covered rather completely in the seventh and eighth grades can only be introduced. Their thorough treatment will have to be given in the ninth grade. Aspects of such topics as informal geometry, area and volume measurement, savings, insurance, and the like may replace some of the usual material of an elementary algebra course.

In the third place, the desire to give as many students as possible experiences in mathematics and the capable students four years of a sound mathematics program imposes further conditions. It is taken almost for granted that ninth grade mathematics should be planned so 100% of the students elect mathematics. The tenth grade course should be designed to appeal to a maximum group of students as an elective and to teach a substantial amount of mathematics. By the end of the tenth year those students should be discovered who should be encouraged to study mathematics for one or two years more. Lastly, the program ought to be so designed that by the end of the eleventh year the concepts of elementary algebra, geometry, intermediate algebra, and trigonometry are studied thoroughly.

Proposed Solution of the Problem

During the past ten years many groups have grappled with the problem of the junior-senior high school mathematics program. One of the first of the more imaginative approaches to a solution is that of the Southern California Experimental Program[2] which proposed a triple track of mathematics that allowed switch-overs from one track to another. Instead of pointing out all the excellent aspects of the program, let us point out two ways in which it fails to meet the conditions stated in the formulation of the problem. This solution neglects the problem of the small high school, because the small high school can handle only a single track. In addition, this solution of the problem does not provide a student with an opportunity to study mathematics beyond trigonometry. However, there is much merit in the solution; it indicates a willingness to break with traditional organizations of high school mathematics and proposes alternatives that have received much praise.

The second proposed solution that will be considered came out of a study of the problem by a competent group of Florida mathematics teachers; their bulletin, titled *Functional Mathematics in the Secondary Schools*[3] discusses in some detail the grade placement of topics. The group recognized the condition imposed by the small high school and proposed a single track for everyone. There is some question whether the program satisfactorily takes care of the mathematical needs of the group of students pointed in the direction of technical training.

Recently the first publication of a third proposed solution appeared.

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[2] Dale Carpenter and Charles Fabing, "The Experimental Mathematics Program," *California Journal of Secondary Education*, XXIII (Nov. 1948), pp. 429–432; or Dale Carpenter, "Planning a Secondary Mathematics Curriculum to Meet the Needs of All Students," *The Mathematics Teacher*, XLII (Jan. 1949), pp. 41–48.

[3] *Functional Mathematics in the Secondary Schools*. Florida Program for Improvement of Schools, Bulletin No. 36. Tallahassee, Florida: State Department of Education, 1950.

It is the result of careful thought and investigation by a large number of persons in New York State and has the title, *Mathematics for All High School Youth.*[4] This publication presents the philosophical and psychological background for its proposal of a two-strand program of mathematics running through grades 9–12. Although this proposal seems to neglect the situation of the small high school, still a large section is devoted to suggestions for solving its problems. It should be pointed out that this publication does not include grade placement charts of topics; working out specific suggestions for a mathematics program is left to subsequent publications. At the present time committees are working on these reports, and soon there will appear a definite suggestion of a program for grades 10, 11, and 12.

At the University of Illinois much thought has been given to the problem under consideration in this paper. Several publications have appeared[5] and indications are that more will follow. In Illinois an effort is being made to work out a single strand of mathematics for grades 9–12. The only prerequisite for the planned course is that a student come to the ninth grade with normal competence in arithmetic and having a knowledge of work with decimal fractions and percentage. From what this writer has heard of the content of the ninth grade course, he draws the tentative conclusion that it is overweighted in the direction of taking care of the needs of the technical group. However, it must be emphasized that this is a tentative conclusion only, based on inadequate knowledge of details. The writer is sincere in his praise of the imagination shown by the Illinois committee and is impressed by the amount of sound mathematics that is being put into the program.

In view of what has been done and in view of the conditions imposed by the formulation of the problem, it seems as if a single strand mathematics program is required by the small high school. Since the seventh and eighth grade teachers are going to be responsible for teaching more arithmetic than heretofore, some of the material formerly taught in these grades must find a place in the ninth grade. Since the ninth grade mathematics class will include almost all the students, the material studied must be of interest to almost all, of value to almost all, and of not too high a mathematical maturity level. Hence, it is proposed that a program be planned that has an accelerating rate of difficulty from the beginning of the ninth grade through the eleventh grade. The rate of difficulty will be slow during

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[4] *Mathematics for All High School Youth.* Albany, N. Y.: The State Education Department, Bureau of Secondary Curriculum Development, 1953.

[5] *Mathematical Needs of Prospective Students at the College of Engineering of the University of Illinois.* University of Illinois Bulletin, XLIX, No. 18. Urbana, Illinois: University of Illinois, 1951; or, Kenneth B. Henderson and Kern Dickman, "Minimum Mathematical Needs of Prospective Students in a College of Engineering," *The Mathematics Teacher,* XLV, (February 1952), pp. 89–93.

the ninth grade, increasing only gradually. In the tenth and eleventh grades the rate of difficulty will increase uniformly. You might think of a curve plotted on axes with time (ninth, tenth, eleventh grades) along the horizontal axis and difficulty along the vertical axis. Then the curve would have a small initial slope that increases gradually during the ninth grade and a uniformly steeper or larger slope through the tenth and eleventh grades.

Communication of the Solution

This brings us to the question of what topics to include in the program, in short, a grade placement chart. There follows a proposed selection of topics for each of the grades in question.

Ninth Grade

Recapitulation of fundamental operations of arithmetic with whole numbers, fractions, and decimal fractions on a maturity level appropriate to ninth graders
The linear equation
Informal geometry, including properties of common plane and solid figures, formulas for area or surface or volume, and constructions
Graphs and elementary statistics
Measurement, including the elements of computation with approximate numbers
Mathematics of the home, business, and government
Directed numbers
Factoring and special products, including the solution of a quadratic equation by factoring
Ratio, proportion, and variation
Numerical trigonometry, but no interpolation, using sine, cosine and tangent ratios
System of two equations in two unknowns
Exponents, including the extension of the definition of an exponent to include zero and negative exponents
Simple radicals

Tenth Grade

Elements of deductive logic, emphasizing at appropriate points in the course such concepts as undefined terms, definitions, assumptions, what constitutes a proof, converse, inverse, contrapositive, and necessary and sufficient conditions.
Geometry of the triangle, parallel lines, the circle, angle measurement, and similar figures
Areas
Numerical trigonometry, including interpolation in a four-place table of trigonometric functions for the sine, cosine, and tangent ratios
Elements of analytic geometry
Locus
Inequalities
Regular polygons

Eleventh Grade

Systems of two and three equations in two and three unknowns, repectively, including solution by determinants

Concept of a function, including functional notation, direct, and inverse variation
Factoring and special products at a more advanced level than in the ninth or tenth grade
Exponents
Radicals, including the extension of an exponent to a rational number
Complex number system
Quadratic equations, including solution by formula, the discriminant, the sum and product of the roots, and the equation of the axis of symmetry
Systems of quadratic equations
Computation with approximate numbers
Logarithms
Trigonometric solution of right triangles using logarithms
Definitions of six trigonometric functions of a general angle
Radians
Properties of the trigonometric functions, including graphs and reduction formulas
Simple trigonometric identities and equations
Inverse trigonometric functions
Trigonometry of the oblique triangle
Multiple angle formulas
Sequences, series, and the binomial theorem

A great deal of repetition of material now exists in the mathematics program of grades 9, 10, and 11. If concepts appropriate to these grade levels are taught in such a way that students know what the concepts mean and understand them, much of the repetition of material can be eliminated. The *concepts* can be repeated but their applications can be different. By eliminating the repetition of material space can be found in the course of study for development of new concepts and for higher level applications of concepts learned earlier.

Much evidence exists that less practice work or drill is necessary when concepts are emphasized in mathematics teaching. It is not intended to imply that practice work can be dispensed with; not at all, but less time needs to be spent on attempts to "fix bonds." More research needs to be done, however, before a definitive answer to this question of developmental versus deductive teaching can be given.

It is believed that the outline of topics for grades 9, 10, and 11 presented here comes closer to satisfying the conditions of the problem than any other plan. The predicament of the small high school is recognized; the need for more mathematics for future technical workers is provided for; and the topics displaced from the seventh and eighth grade find a place in the ninth grade. Admittedly this proposal is a compromise. Two or three strand programs are much better when size of a high school justifies employment of a sufficient number of teachers to carry them out. Our solution takes care of the mathematical needs of a large percentage rather than 100% of the

students in grades 9, 10, and 11; it recognizes that there are many students capable of benefiting from study of mathematics; and it provides for them as well as for slow learners in mathematics.

WATER FIT TO DRINK? ATOMIC SCIENTIST REPORTS FINDINGS

The tipsy gentleman who recoiled at the thought of drinking water because "look how it rusts pipes," would have been further appalled at the latest word of scientists.

Dr. D. E. Thomas of the Westinghouse Atomic Power Division, Pittsburgh, Pa., told the American Institute of Chemical Engineers' Nuclear Engineering Congress that his firm's work on the first atomic submarine engine and other studies have shown water to be even more corrosive when very hot and under pressure.

Such metals as aluminum and magnesium, he said, are "completely disintegrated after a few hours in 600 degree Fahrenheit water." When not under pressure, water boils at 212 degrees.

Fortunately for the atomic engine builders, however, the metal zirconium proved able to withstand the corrosive attack of this "superheated" water, Dr. Thomas pointed out. Although poor grades of zirconium may disintegrate after a few days exposure, he said, "better grades may exhibit only slight attack" after a full year.

Thus zirconium was used as an important structural material in the atomic engine Westinghouse built for the Atomic Energy Commission and which will power the atomic submarine Nautilus. In this nuclear power plant, water circulates through the hot "uranium furnace" and carries the heat to a heat exchanger or boiler where steam is generated to drive steam turbines.

Studies have shown that impurities in zirconium weaken its corrosion resistance, Dr. Thomas reported, and so does any machining of the metal's surface. These zirconium corrosion studies, he said, have been a cooperative venture among the AEC's Metailurgy Project at Massachusetts Institute of Technology, Argonne National Laboratory, Battelle Memorial Institute, U. S. Bureau of Mines at Albany, Oregon, and Westinghouse.

POTENTIAL SCIENTISTS LOST AT HIGH SCHOOL LEVEL

Lack of qualified science teachers and shortage of adequate laboratory equipment are causing America to lose thousands of potential scientists at the high school level.

Dr. Francis D. Curtis, emeritus professor of education at the University of Michigan who taught during the summer at the University of California at Los Angeles, declared here:

"There is a pressing need in the United States for thousands more engineers, chemists, physicians, physicists and other scientifically-trained personnel."

If he had his way, schools would require all pupils to take general science, general biology and general physical science in the 8th, 9th and 10th grades, respectively. This sequence would make possible more advanced science courses in high school for those who want to prepare for scientific careers.

"In the smaller high schools especially," he pointed out, "our courses in physics and chemistry are of necessity watered down because pupils of all ability levels must take them."

Some of the blame for the critical shortage of high school science teachers must be assigned to the colleges, Dr. Curtis believes. In his opinion, they have concentrated too much on turning out highly-trained scientific specialists and have largely ignored the need for scientific generalists qualified to enter teaching.

RAPID SURVEY OF EATING HABITS—A STIMULUS TO NUTRITION EDUCATION[1]

M. J. Babcock and Lorraine Owen Gates
Rutgers University, New Brunswick, N.J.

One of the greatest challenges that faces nutritionists today is teaching the basic facts of nutrition to the lay public. The widespread acceptance of the claims of food-faddists is ample proof that our educational program is not effectively reaching large numbers of persons. The reasons are complex, but prominent among them is the fact that the information to be conveyed is not spectacular. In a world of high-pressure advertising, action-packed programs on the radio, television, and movies, and momentous newspaper headlines, conservative statements on a subject such as nutrition are too frequently overlooked by many persons.

The fact that the attrition of mild, chronic malnutrition, the only form of malnutrition common in this country, is not obvious to the layman allows him to develop a skeptical attitude toward the importance of nutritional knowledge. He is inclined to feel that findings of nutrition surveys are abstract statistics that pertain only to "the other fellow." Much of this feeling might be overcome if a survey were based on facts gathered directly from him, from members of his family, and from his neighbors. It is obviously impossible, however, to finance comprehensive nutritional surveys for more than a few isolated groups of persons in the country. To bring such studies to many communities, it would be necessary to simplify the procedures to the point where they could be administered and the results interpreted by untrained personnel working through existing agencies. This paper presents detailed procedures for conducting an eating habits survey designed to meet these objectives, and it gives the results of such a study conducted in one New Jersey county.

The school system is well adapted for administration of questionnaire-type surveys because it has a well-organized group of cooperative and intelligent personnel, and it reaches children representative of nearly all population groups. The schools are in position to follow up readily the findings with practical measures for improvement. Furthermore, studies in the schools have the advantage of emphasizing nutrition to two very important groups—children, whose nutritional requirements are critical, and teachers, whose knowledge is passed on to hundreds of others.

To obtain valid information on eating habits with a minimum of

[1] Paper of the journal series, New Jersey Agricultural Experiment Station, Rutgers University, The State University of New Jersey, Department of Agricultural Biochemistry, New Brunswick, New Jersey.

instruction to the children, it is necessary to select an age group that is cooperative and familiar with questionnaires. The sixth grade was considered to be most suitable on this basis, but to obtain a more homogeneous group in the New Jersey study, the data were collected from pupils in the seventh grade or from combined classes containing sixth, seventh, and eighth grade pupils.

The study reported here was made in April, 1953, by the New Jersey Nutrition Council in cooperation with the Department of Education of Hunterdon County. Questionnaires were given to 26 classes throughout the county by the seventh grade teachers. Each teacher tabulated the answers for her class and sent both the original questionnaires and the tabulated data to the County Superintendent of Schools, who forwarded them to the New Jersey Nutrition Council. Volunteer workers from the Nutrition Council checked the tabulations where necessary, calculated the averages, converted the data to percentages to facilitate comparisons, and prepared graphs of the findings for each class and for the county. Details of the procedure follow.

The questionnaire used (Figure 1) was adopted from the "basic seven" food grouping to simplify application of the findings in the follow-up teaching. Simple, multiple-choice questions were chosen to facilitate the tabulation of results. In addition to providing information on foods eaten, this questionnaire was designed to rate each child's diet approximately on its content of the following important nutrients: protein, ascorbic acid (vitamin C), calcium, and riboflavin (vitamin G). Since milk is the main source of calcium and riboflavin in children's diets, the amount of milk consumed provided a basis for rating the diets on these nutrients. Protein and vitamin C, however, are usually supplied by a variety of foods, and ratings of the diet for these nutrients must take into account contributions from several important food sources. Code numbers were used to give the relative amounts of protein and ascorbic acid in the major dietary sources of these nutrients. By adding these code numbers, it was possible to obtain a rough estimate of the amounts of protein and ascorbic acid in each child's diet. Since vitamins of the B-complex tend to accompany protein, the protein score was also helpful in judging the diets with respect to these vitamins.

The code numbers for the protein and ascorbic acid scores were based on the weighted average values of Leichsenring and Donelson (1951). Consideration was given to the usual serving sizes and importance of the foods in children's diets. It is obvious that the kind of data collected with this questionnaire, together with the many assumptions and approximations made in estimating the nutrient contents of the diets, precludes any quantitative estimations of the nu-

tritive values of the diets. However, as the recommended numbers of servings of the various food groups gave a total protein score of 14 and a total vitamin C score of 7, these values were adopted as the "recommended amounts" for qualitative interpretation of the data. The rating of diets according to their nutrient contents enhances the value of an eating habits survey, particularly because in the follow-up educational programs it focuses attention on the nutritive values and roles of various foods in the diet.

FIG. 1. QUESTIONNAIRE

SCHOOL ..... YOUR GRADE .....

HOW OFTEN DO YOU EAT THE FOLLOWING?

Code no.		
	Milk:	
0	Seldom	____
1	Every other day	____
2	Once a day	____
4	Twice a day	____
6	Three or more times a day	____
	Breakfast cereals:	
0	Seldom	____
½	Every other day	____
1	Once a day	____
2	Twice a day	____
3	Three or more times a day	____
	Bread or rolls:	
0	Seldom	____
½	Every other day	____
1	Once a day	____
2	Twice a day	____
3	Three or more times a day	____
	Eggs:	
0	Seldom	____
1	Every other day	____
2	Once a day	____
4	Twice a day	____
6	Three or more times a day	____
	Meat, Fish, Poultry; Baked Beans:	
0	Seldom	____
2	Every other day	____
4	Once a day	____
8	Twice a day	____
12	Three or more times a day	____
	Protein total	____

Code no.		
	Butter or margarine:	
	Seldom	____
	Every other day	____
	Once a day	____
	Twice a day	____
	Three or more times a day	____
	Citrus fruits:	
	Oranges, grapefruit, or their juice:	
0	Seldom	____
3	Every other day	____
6	Once a day	____
12	Twice a day	____
18	Three or more times a day	____
	Tomatoes, fresh, canned or juice; raw cabbage; leafy greens, raw or cooked:	
0	Seldom	____
1½	Every other day	____
3	Once a day	____
6	Twice a day	____
9	Three or more times a day	____
	Green or yellow vegetables:	
	Examples: Green beans or peas, carrots, sweet potatoes, squash.	
0	Seldom	____
½	Every other day	____
1	Once a day	____
2	Twice a day	____
3	Three or more times a day	____
	Potatoes, other vegetables and fruits: All fruits or vegetables (fresh, frozen, canned, juice, or dried) not counted above. Examples: Celery, beets, corn, onions, lettuce, apples, bananas, pineapple.	
0	Seldom	____
½	Every other day	____
1	Once a day	____
2	Twice a day	____
3	Three or more times a day	____
	Vitamin C total	____

In the New Jersey study, it was not feasible to explain the procedures directly to the teachers, but excellent cooperation was obtained from the teachers by instructions sent out by the County Superintendent covering the following points:

(1) Children's names are not to appear on the questionnaires.

(2) Children should check the ONE statement in each food group that most nearly applies. They are to disregard the code numbers.

(3) Teachers should explain that the questions refer to the usual size servings. For milk an 8 oz. glass is considered one serving; for bread, one slice. Two eggs for breakfast would be "twice a day." The teachers should also point out that lettuce and corn are classified in the last food group rather than in the preceding two groups. Good nutrition practices should not be discussed until after the questionnaires are collected.

(4) The code numbers to the left of each column give the relative amounts of protein and vitamin C supplied by average size servings. The code numbers (none for butter) corresponding to each item checked by a child should be added by the teacher and the totals for each column entered in the spaces provided at the bottom of the page.

(5) All data on the questionnaires should be tabulated for the class. That is, give the number of times each of the fifty blanks was checked, and also give the number of pupils who received each protein and vitamin C score. For uniformity, the tabulations should be made on a copy of the questionnaire, with the protein and vitamin C scores listed on the back.

When the questionnaires and tabulated data for each class were received by the Nutrition Council, a workshop meeting was held to consolidate and interpret the data. The first step was to check the teachers' tabulations by the number of pupils she reported in each section of the questionnaire. Thus, if 28 children marked answers for the milk group, there should be 28 answers for each of the other food groups and nutrient scores. Discrepancies were checked against the original questionnaires.

The average number of times each food was eaten by each class was calculated by counting "seldom" as zero, "every other day" as $\frac{1}{2}$, "once a day" as 1, "twice a day" as 2, and "three or more times a day" as 3. Next, the number of children who marked each answer was converted to a percentage of the class with the aid of Table 1. For example, if 7 children out of a class of 28 had milk twice a day, the percentage, 25%, is found by following across dividend line 7 to divisor column 28. If the total of these percentages for each food group did not come out to be 99%, 100%, or 101%, the calculations were checked. The slight deviation from the theoretical 100%, sometimes caused by rounding of the percentages in Table 1, was disregarded.

The averages and percentages for each class were plotted as illustrated in Figure 2, although the data shown in Figure 2 are for the total county. As a visual aid, red pencils were used for values below the recommended number of servings and blue pencils for all higher

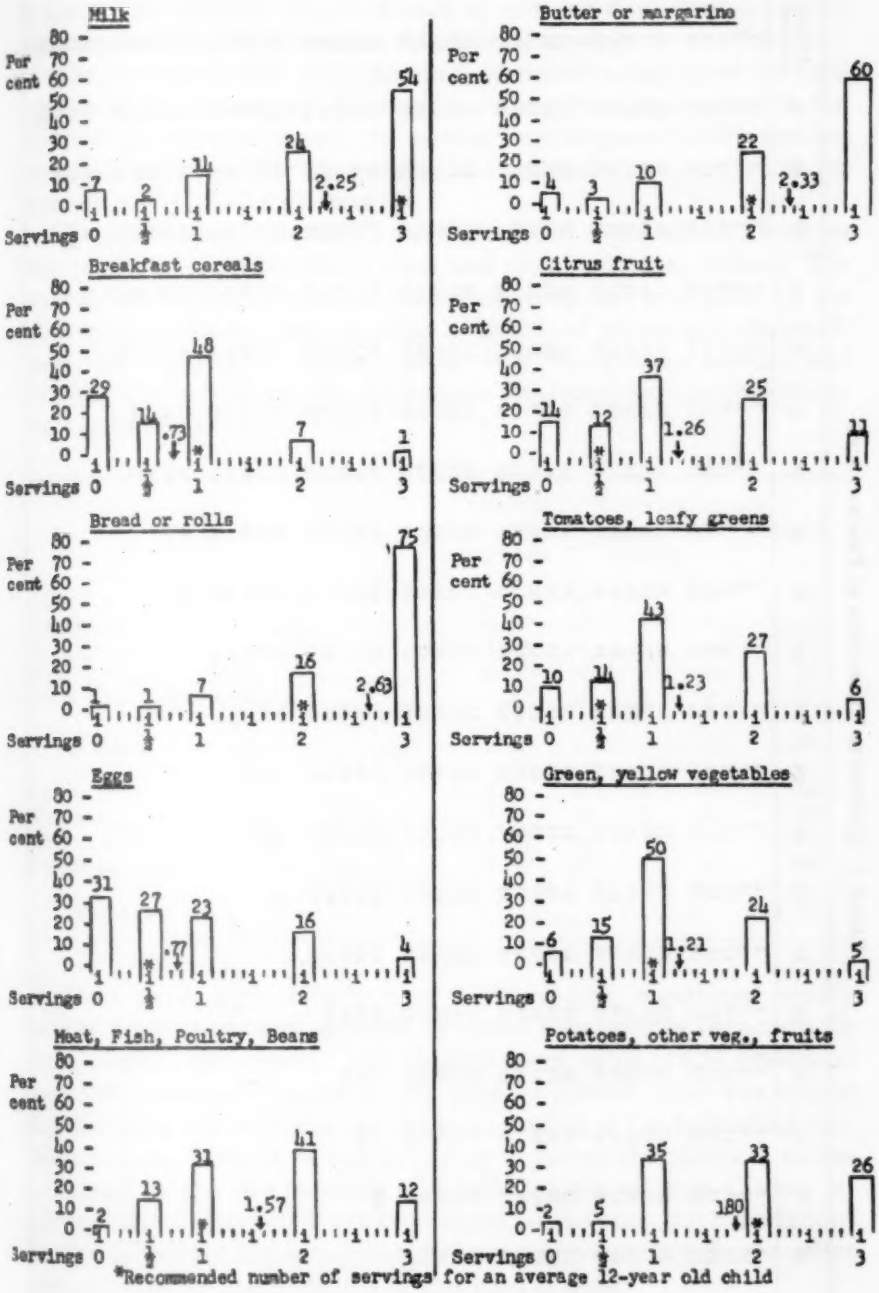

FIG. 2. Dietary pattern of seventh grade school children in Hunterdon County.

TABLE 1. QUOTIENTS EXPRESSED AS PERCENTAGES

Divisor / Dividend	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Divisor / Dividend
1	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	1
2	10	10	9	9	8	8	8	7	7	7	7	6	6	6	6	6	6	5	5	5	2
3	15	14	14	13	12	12	12	11	11	10	10	10	9	9	9	9	8	8	8	8	3
4	20	19	18	17	17	16	15	15	14	14	13	13	12	12	12	11	11	11	11	10	4
5	25	24	23	22	21	20	19	19	18	17	17	16	16	15	15	14	14	14	13	13	5
6	30	29	27	26	25	24	23	22	21	21	20	19	19	18	18	17	17	16	16	15	6
7	35	33	32	30	29	28	27	26	25	24	23	23	22	21	21	20	19	19	18	18	7
8	40	38	36	35	33	32	31	30	29	28	27	26	25	24	24	23	22	22	21	21	8
9	45	43	41	39	38	36	35	33	32	31	30	29	28	27	26	26	25	24	24	23	9
10	50	48	45	43	42	40	38	37	36	35	33	32	31	30	29	29	28	27	26	26	10
11	55	52	50	48	46	44	42	41	39	38	37	35	34	33	32	31	31	30	29	28	11
12	60	57	55	52	50	48	46	44	43	41	40	39	38	36	35	34	33	32	32	31	12
13	65	62	59	57	54	52	50	48	46	45	43	42	41	39	38	37	36	35	34	33	13
14	70	67	64	61	58	56	54	52	50	48	47	45	44	42	41	40	39	38	37	36	14
15	75	71	68	65	62	60	58	56	54	52	50	48	47	45	44	43	42	41	39	38	15
16	80	76	73	70	67	64	62	59	57	55	53	52	50	48	47	46	44	43	42	41	16
17	85	81	77	74	71	68	65	63	61	59	57	55	53	52	50	49	47	46	45	44	17
18	90	86	82	78	75	72	69	67	64	62	60	58	56	55	53	51	50	49	47	46	18
19	95	90	86	83	79	76	73	70	68	65	63	61	59	58	56	54	53	51	50	49	19
20	100	95	91	87	83	80	77	74	71	69	67	65	62	61	59	57	56	54	53	51	20
21		100	95	91	88	84	81	78	75	72	70	68	66	64	62	60	58	57	55	54	21
22			100	96	92	88	85	81	79	76	73	71	69	67	65	63	61	59	58	56	22
23				100	96	92	88	85	82	79	77	74	72	70	68	66	64	62	61	59	23
24					100	96	92	89	86	83	80	77	75	73	71	69	67	65	63	62	24
25						100	96	93	89	86	83	81	78	76	74	71	69	68	66	64	25
26							100	96	93	90	87	84	81	79	76	74	72	70	68	67	26
27								100	96	93	90	87	84	82	79	77	75	73	71	69	27
28									100	97	93	90	88	85	82	80	78	76	74	72	28
29										100	97	94	91	88	85	83	81	78	76	74	29
30											100	97	94	91	88	86	83	81	79	77	30
31												100	97	94	91	89	86	84	82	79	31
32													100	97	94	91	89	86	84	82	32
33														100	97	94	92	89	87	85	33
34															100	97	94	92	89	87	34
35																100	97	95	92	90	35
36																	100	97	95	92	36
37																		100	97	95	37
38																			100	97	38
39																				100	39

values. The averages (e.g. 2.25 cups of milk per day) were shown by arrows, and the recommended numbers of servings by asterisks.

The average protein and vitamin C scores were calculated for each class and for the county. To avoid handling fractional values in the individual subjects' scores, the halves were dropped before making the class averages. For the county, the average scores were 15.54 for protein and 14.26 for vitamin C.

The protein and vitamin C scores provided a convenient check on the previous compilations of class and county data as follows: The average number of servings in each food group was multiplied by the code number for one serving a day of that food group, and the products were totaled to obtain checks with the average protein and vitamin C scores. These calculations are illustrated here for the county data given in Figure 2:

	Average no. of servings		Code no. for one serving		Product
Milk	2.25	×	2	=	4.50
Breakfast cereals	0.73	×	1	=	0.73
Bread or rolls	2.63	×	1	=	2.63
Eggs	0.77	×	2	=	1.54
Meat, fish, poultry, beans	1.57	×	4	=	6.28
Total					15.68
Citrus fruit	1.26	×	6	=	7.56
Tomatoes, leafy greens	1.23	×	3	=	3.69
Green, yellow vegetables	1.21	×	1	=	1.21
Potatoes, other vegetables, fruits	1.80	×	1	=	1.80
Total					14.26

These totals agree closely with the previously mentioned county scores, which had been obtained by direct averaging of the scores for each class in the county. The slightly lower value (15.54 compared to 15.68) obtained for the county average protein score was caused by dropping the halves in the direct averaging of the individual subjects' scores. Because of this dropping of halves the identical values obtained by the two methods of calculating the vitamin C score indicate that a very small error occurred somewhere. Such deviations in the values are not important, however, because they do not affect the qualitative interpretation of this kind of data.

The findings for Hunterdon County were consolidated from the data for the 26 classes in the county in the same manner that the findings for each class were consolidated from the data for individual

children. The average number of servings of each food group eaten per day and the percentages of children who ate different numbers of servings per day are given in Figure 2. This chart was sent to each teacher along with a similar chart drawn for her class so she could compare the findings for her class with those for the county and the recommended dietary pattern. To provide an example of the interpretation of these charts, each teacher was given the following description of the county results:

HIGHLIGHTS FROM AN EATING HABITS SURVEY OF HUNTERDON COUNTY SCHOOLCHILDREN

A survey of the eating habits of some Hunterdon County schoolchildren was made in April, 1953, by the New Jersey Nutrition Council in cooperation with the Department of Education. Working through the County Superintendent of Schools, the Helping Teachers and a group of 7th grade teachers, the Council asked more than 700 children in 7th grade classes to check how frequently they ate each of the types of food that go into making up a balanced diet. They compared the results obtained from each of 26 schools throughout the county with the amounts of each type of food recommended for good health, and found that while most of the children were well-fed, a significant number had poor eating or dietary habits.

Some Lacked Milk

Let's look at the figures. We all know the importance of milk in the diet of growing children and that it is recommended they have the equivalent of a quart of milk per day. Figuring that they will get about one cup of milk each day as an ingredient of cooked foods, that leaves 3 cups (8 oz. glasses) per day that a child should drink as fluid milk. Hunterdon County children said they drank an average of two and a quarter cups of milk per day. A little over half of the children said they consumed the recommended 3 or more cups per day. However, one out of every 16 children said he seldom had milk!

How about Eggs?

With eggs, the average picture is better. The standard for a teen-age child is three eggs a week, or an average of about one-half egg per day. In this poultry-producing county, the children said they ate an average of three-fourths of an egg per day. But averages are misleading, because they don't tell how many are eating more and how many are eating less than the recommended amount. Although the county average for eggs was high, in two schools sixty per cent of the children said they seldom ate eggs. Elsewhere in the county nearly one-fourth of the children seldom ate eggs.

One serving of meat, poultry or fish is recommended per day, and 85 per cent of the children in Hunterdon County said they ate that much. The averages for all schools in the county were greater than one serving, and for the county the average was as high as one and one-half servings per day.

Does it Balance?

Now these figures raise an interesting question. Could it be that the children who drink less milk than is desirable are eating more eggs and meat, which might make up for the nutrients they lose in low milk consumption? For the answer, let's look at two critical nutrients—calcium which is needed for forming strong bones, and protein, which is required to build muscle and other tissues of the body. While small amounts of calcium are present in many foods, the best source of calcium is milk. It's almost impossible to supply a child with the recom-

mended amount of calcium without providing the daily allowance of milk, or its equivalent in cheese or ice cream.

Unlike calcium, protein can come from many sources. The animal foods are good sources of protein, and animal proteins go farther when supplemented with vegetable proteins obtained from bread, cereals and legumes. To find out whether children in Hunterdon County are getting enough total protein from all sources, each child's questionnaire was rated according to the total protein supplied by the various types of foods eaten. The average protein score for all children in the county was a little higher than the recommended score, and for no school was the average very far below the recommended level.

Here again, these averages do not mean that all the children were receiving adequate protein. One out of every three children ate less than the recommended amount of protein, and one out of every seven children ate less than three-fourths of the recommended amount. Furthermore, since vitamins of the B-complex tend to accompany protein, this finding suggests that some children may not be receiving enough of these vitamins.

Fruits and Vegetables

Turning now to the fruits and vegetables, sources of important minerals and vitamins, most of the children said they ate citrus fruit, tomatoes and greens in quantities well over the recommended levels and slightly less of other vegetables and fruits, which have lower nutritive values. When each child's questionnaire was rated according to the total vitamin C (ascorbic acid) supplied by all fruits and vegetables, high scores were obtained for all schools. Still, 16 per cent of the children in the county ate so little fruits and vegetables that their vitamin C intake was less than the recommended amount and 12 per cent of the children received less than three-fourths of the recommended amount. In one-third of the schools the questionnaires indicated that 10% of the children received less than half of the recommended amount of vitamin C.

Tomatoes and green leafy vegetables, along with butter or margarine, are also important in the diet as sources of vitamin A. Most of the children ate enough butter or margarine.

School Lunches Help

Did schools that served hot lunches have better-nourished children than those that did not? Yes, where a school lunch program was in effect, the children's answers to the questionnaire indicated that on the average they consumed slightly more milk, meat, butter and vegetables, and slightly less cereals and bread. The average consumption of eggs and citrus fruit was approximately the same in both groups of schools. The average protein and vitamin C scores were slightly higher for the school lunch group. Also, in schools that served lunches more of the children received the recommended amounts of protein and vitamin C.

While the average consumption of the protective foods was slightly higher in schools that served lunches, relatively high numbers of the individual children in these schools said that they seldom ate eggs, had only one glass of milk per day, or ate little fruit and vegetables.

Summary

In summary, questionnaires filled out by seventh grade school children in Hunterdon County indicated that most of the children had good eating habits, with plenty of meat, citrus fruit, tomatoes, green vegetables, bread and butter in their diets. However, the consumption of milk was somewhat lower than recommended, and many children did not eat enough eggs, with the result that one-third of the children received less calcium and protein than is considered desirable for growing children. While the majority of the children rated high as far as fruits and vegetables are concerned, one-sixth ate so little that their vitamin C

intake fell below the recommended level. Children in schools that served hot lunches had, on the average, slightly better eating habits than children in other schools.

Such findings indicate that the problems of healthy growth through adequate nutrition are concentrated in a small segment of the school population and thus could be attacked by P.T.A.'s and school authorities with effective results.

Each teacher was also supplied with a list of government and commercial material suitable for nutrition education purposes. All of the material sent to the teachers, except the results from the individual classes, was also distributed through the County Superintendent of Schools to the parent-teacher associations, the press, and other interested groups. The hope was, of course, that this material would provide a starting point for numerous discussions of practical nutrition problems. The natural curiosity of children, parents, and teachers to see how their group compares with other groups and the recommended standards should lead to analyses of why differences exist and what can be done to improve further the nutritional welfare of the children. Lane (1952) has shown that nutrition survey results are effective in improving high school students' diets.

In addition to benefits to individuals who participate in or read about surveys of this type, the data on eating habits should be helpful to local, state, and national agencies concerned with health and welfare of the populace. Although the information on food consumption obtained from this simplified type of survey is not as precise as that for a comprehensive dietary study in which the foods are quantitatively weighed or measured, the latter type of study is necessarily restricted to a small sample, which frequently is not representative of the population. The very fact that subjects are required to keep detailed records usually eliminates certain groups of subjects who lack the education, the time, or the incentive required to prepare the records. The school survey described here, on the other hand, included all school children (except a few absentees) in the specified grades in all schools in the county. The findings are, therefore, based on a sample that is both large and representative of all parts of the county. This type of survey could also be used as a basis for sampling a population for more comprehensive nutrition surveys.

Summary

The use of questionnaire-type surveys of eating habits is proposed as a means of stimulating the interest of large groups of persons in practical nutrition problems.

A questionnaire designed for conducting such a survey of school children is presented along with detailed directions for tabulating and interpreting the data. Special features of this questionnaire are that

it may be easily applied by personnel without special training, it provides dietary information in terms of several nutrients, as well as foods, and the procedures include a check of the arithmetic involved in the tabulations. The questionnaire is suitable for rating the eating habits of school children individually, by classes, and by large samples in which all geographic areas of a school system are represented.

The findings from a survey of the eating habits of school children in Hunterdon County, New Jersey, are given as an example of how this type of data may be interpreted.

Acknowledgments

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LARGE RADIO TELESCOPE NOW SCANNING HEAVENS

A new telescope capturing radio waves is now scanning the heavens for invisible "stars." It is the largest radio telescope in the world to scan the sky in the 20 megacycle (14 meters) range.

Built by Carnegie Institution of Washington, it consists of 128 TV-like antennas arranged in a giant X, spanning 2,040 feet, in a 90-acre field at Seneca, Md. Dr. F. Graham Smith, a visiting scientist from Cavendish Laboratory, Cambridge University, England, and Drs. Harry W. Wells and Bernard F. Burke of the Institution's Department of Terrestrial Magnetism supervised the radio telescope's construction.

It will be used for the study of radio radiations not only from the sun and other radio sources in our Milky Way galaxy, but also of radio noise coming from other, far distant galaxies.

Radio waves are emitted even by some heavenly objects that do not give off light. Radio waves also penetrate where light can not. By combining the radio and light methods of surveying the heavens, astronomers are learning more about how the universe is put together.

THE READING DIFFICULTY OF TEXTBOOKS FOR GENERAL PHYSICAL SCIENCE AND EARTH SCIENCE

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It is common knowledge that, over the years, textbooks have been among the primary sources for the subject-matter materials taught in the classroom. It is also well-known that these sources have been used with varying degrees of success depending on (1) the teacher's ability to use them effectively, and (2) the quality of the textbook. Quality, of course, is related to a vast number of factors as is shown in a report by Vogel.[1] Among such factors there is one of paramount importance to educators, namely, that of reading difficulty. The importance attached to this factor is eminently justified, since no matter how well a textbook is written, it is not likely to be of great value if the children have great difficulty reading it.

Recently, a number of research workers have investigated this characteristic of textbooks, especially of those in the area of science. The studies[2,3,4,5,6,7,8,9] undertaken on science textbooks reveal the following:

1. The reading levels of many textbooks in science are too advanced for students for whom they are written.

2. The differences between the levels of reading difficulty of the easiest and the most difficult textbooks in any area of science are significant.

3. In some textbooks of science whose *average* level of reading diffi-

[1] Vogel, Louis F., "A Spot-Check Evaluation Scale for High School Science Textbooks." *The Science Teacher*, XVIII (March 1951), 70–72.

[2] Mallinson, George Greisen, "Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science." SCHOOL SCIENCE AND MATHEMATICS, LII (April 1952), 269–74.

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[4] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois M., "The Reading Difficulty of Textbooks in Junior High School Science." *School Review*, L (December 1950), 536–40.

[5] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois Marion, "The Reading Difficulty of Textbooks for General Science." *School Review*, LII (February 1952), 94–8.

[6] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois Marion, "The Reading Difficulty of Textbooks for High-School Biology." *The American Biology Teacher*, XII (November 1950), 151–56.

[7] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois Marion, "The Reading Difficulty of Textbooks for High-School Chemistry." *Journal of Chemical Education*, XXIX (December 1952), 629–31.

[8] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois Marion, "The Reading Difficulty of Textbooks for High-School Physics." *Science Education*, XXXVI (February 1952), 19–23.

[9] Mallinson, George Greisen, Sturm, Harold E. and Patton, Robert E., "The Reading Difficulty of Textbooks in Elementary Science." *Elementary School Journal*, L (April 1950), 460–63.

culty seems satisfactory, there are passages that would be difficult even for some college students.

4. Many textbooks of science contain non-technical words that could be replaced with easier synonyms.

However, none of these studies deal with textbooks in the areas of general physical science or earth science. Yet, both of these areas, especially general physical science, have grown rapidly during the last several years. Hence, it was decided that information from an analysis of these textbooks might well suggest the grade levels at which students can make use of them most effectively.

Thus, a search was made to locate the titles of textbooks designed for use in general physical science and earth science. The search revealed eleven in general physical science and seven in earth science, all of which were used in this investigation. Since analysis of all the textual material in all the textbooks was impractical, a modification of the sampling technique suggested by Flesch[10] for use with his formula was employed.

It was decided to select from each textbook one sample passage for each one hundred pages or fraction thereof, but not less than five passages from any one textbook.

The number of pages in each textbook was computed by counting from the first page designated by an Arabic numeral to the last page of the last chapter. Pages upon which were found chapter endings, supplementary activities, and questions were included in the count. Pages upon which were found indexes, glossaries, and tables of contents were excluded.

The number of pages in each textbook was then divided by the number of samples to be taken from the book. In this way each textbook was divided into sections of an equal number of pages. A page was then selected from each of the sections by using a table of random numbers.

A one-hundred-word sample was taken from each page thus selected by counting from the first word of the first new paragraph on that page. If the page contained no reading material, the sample was selected from the next page that did. Legends under illustrations on these pages were disregarded. These samples were then analyzed by use of the Flesch formula.

The Flesch formula takes cognizance of the number of words in the sentences found in the sample passages, the number of personal references (*we*, *they*, etc.) in the passages, and number of affixes and suffixes (syllabification) to the words. These various aspects of sentence structure are measured in each of the one-hundred-word samples and are translated into a reading-difficulty score by means of the formula.

[10] Flesch, Rudolf, *The Art of Plain Talk*. Harper and Bros., New York, 1946, p. 205.

The reading-difficulty score is converted, in turn, into a grade-level value of reading difficulty. The conversion is made by using Table 1.

TABLE 1. GRADE LEVELS OF DIFFICULTY EQUIVALENT TO READING-DIFFICULTY SCORES*

Reading-Difficulty Score	Description of Style	Grade Level of Difficulty
0–1	Very easy	Grade IV Completed
1–2	Easy	Grade V Completed
2–3	Fairly easy	Grade VI Completed
3–4	Standard	Grade VII or VIII
4–5	Fairly difficult	Two Years of High School
5–6	Difficult	High School and Some College
6 and up	Very difficult	College Completed

* Flesch, Rudolf, *op. cit.*, p. 205.

Tables 2 and 3 contain the following information for the textbooks designed for general physical science and earth science respectively: (1) the textbook publishers (designated by the letters A, B, C, etc.); (2) the reading-difficulty scores of the samples taken from the textbooks; (3) the average reading-difficulty score for each textbook; and (4) the grade level of difficulty for each textbook.

TABLE 2. LEVELS OF READING DIFFICULTY OF TEXTBOOKS FOR GENERAL PHYSICAL SCIENCE

Publisher	Reading-Difficulty Score for Sample									Average Reading Difficulty Score*	Grade Level of Difficulty†
	1	2	3	4	5	6	7	8	9		
A	2.78	3.19	3.32	2.28	3.76	4.02	—	—	—	3.23	VII
B	4.65	4.72	4.59	4.42	3.91	2.74	3.15	4.78	3.52	4.05	IX
C	4.23	4.90	5.73	4.06	4.51	4.61	3.84	—	—	4.55	X
D	3.67	4.33	2.96	4.83	4.39	—	—	—	—	4.04	IX
E	4.46	2.67	3.97	3.22	3.60	4.01	—	—	—	3.66	VIII
F	4.83	3.81	4.12	5.04	3.93	2.52	3.16	2.29	—	3.71	VIII
G	3.56	3.93	4.92	3.28	2.51	3.05	3.19	—	—	3.49	VII Completed
H	4.45	3.73	4.12	3.51	3.48	3.41	—	—	—	3.78	VIII Completed
I	3.92	5.23	6.39	4.33	4.01	—	—	—	—	4.78	X Completed
J	4.06	3.70	4.25	3.97	2.64	—	—	—	—	3.72	VIII
K	3.61	2.41	3.30	2.86	3.32	5.04	—	—	—	3.42	VII Completed

* The average reading-difficulty score for all textbooks for general physical science is 3.85, which is equivalent to a grade level of difficulty of about eighth grade completed.

† Grade levels of difficulty were computed by using data in Table 1.

CONCLUSIONS

In so far as the techniques used in this study may be valid, the following conclusions seem defensible.

1. The data in both Tables 2 and 3 indicate clearly that the levels of reading difficulty within the textbooks vary greatly. For example,

TABLE 3. LEVELS OF READING DIFFICULTY OF TEXTBOOKS FOR EARTH SCIENCE

Publisher	Reading-Difficulty Score for Sample							Average Reading Difficulty Score*	Grade Level of Difficulty†
	1	2	3	4	5	6	7		
A	5.41	3.84	4.50	5.73	3.70	—	—	4.64	X
B	2.40	4.46	3.22	3.48	4.52	4.02	—	3.69	VIII
C	3.30	4.46	6.31	3.25	3.26	3.48	—	4.01	IX
D	3.51	3.05	4.06	3.54	5.09	4.07	—	3.89	VIII Completed
E	2.84	2.96	3.15	4.36	5.10	—	—	3.68	VIII
F	3.06	3.89	4.44	2.99	3.31	—	—	3.54	VIII
G	6.57	3.58	4.47	4.39	3.54	3.65	5.75	4.56	X

* The average reading-difficulty score for all textbooks of earth science is 4.02, which is equivalent to grade level of difficulty of about the ninth grade.

† Grade levels of difficulty were computed by using data in Table 1.

in the textbook of general physical sience of Publisher K the easiest passage is of Grade VI in level of difficulty, the most difficult, of college level. In the textbook of earth science of Publisher G the easiest passage is of Grade VIII in level of difficulty, and the most difficult is equivalent to college completed. Nearly all the other textbooks in general physical science and earth science also show a great deal of variation with respect to the levels of reading difficulty of different passages. The same of course was found to be true of the textbooks analyzed in the other studies already mentioned. Hence it is clear that in any textbook some passages are not likely to cause difficulty for any of the students for whom they are designed, whereas other passages are likely to be difficult for even the most superior students.

Obviously, therefore, the average reading-difficulty score of a textbook may prove to be somewhat misleading, since the scores of difficult passages may be balanced by those of easier ones.

2. The average grade levels of difficulty of the textbooks in both general physical science and earth science vary greatly. The easiest textbook in general physical science has an average level of difficulty of Grade VII, the most difficult of Grade X. The easiest textbook in earth science has an average level of difficulty of Grade VIII, the most difficult of Grade X. It must be remembered that in order to be effective the reading difficulty of books must be at least one grade level below that of the students for whom it is designed. Thus it would seem that if general physical science ultimately develops as the general education course in science at the tenth-grade level, many textbooks, in so far as the criterion of reading difficulty is concerned, will be unsuitable.

In the field of earth science a number of writers have suggested that the course may be suitable in the ninth grade in public schools in which elementary and general science courses are well integrated and

organized from grades one through eight. Some of the textbooks available will be suitable for use in the course at this level, others will not.

3. As with the textbooks analyzed in the studies already cited, the earlier passages in the textbooks for general physical science and earth science do not seem to be consistently lower in level of reading difficulty than the later passages. Hence no provision seems to be made for growth of reading ability during the year in which the books are used.

4. In view of the conclusions already stated, it seems reasonable to conclude that the differences found in levels of reading difficulty within and among textbooks make level of reading difficulty a valid criterion for selecting a textbook in the areas of general physcial science and earth science.

A NEW LOW-PRICE DECADE CAPACITOR BOX FOR UNIVERSAL USE IN THE LABORATORY, TEST DEPT., FACTORY AND SERVICE DEPOT

Faced with the problem of considerable expenditure on decade capacitor boxes for a large research and development programme, two development engineers at Winston Electronics, Ltd., Hampton Hill, Middlesex, England, investigated the design of these instruments, starting from fundamentals.

By designing a new type of eleven-position switch—a great saving in bulk and also manufacturing costs was made. An instrument, which can be sold at a much lower price than the cost of constructing "home-made" apparatus in the laboratory or factory resulted, and is now marketed.

Already the Decade Capacitor Box has proved useful in servicing deaf aids; but it should find wide application in electronic circuit designing and building, production control and testing, research and technical laboratories and teaching establishments. In fact, everywhere electrically.

The service engineer in electronics, television or radio will find this small size, extremely light and portable instrument particularly useful.

Technical Specification

Range: 0.001 microfarads to 1.11 mfd., in 0.001 mfd. steps.
Stray Capacitance: Less than 15 pfs per decade.
Working Potentials: 500 volts D.C., except the 0.1 mfd range where it is 350 volts D.C.
Switching: Positive and firm: no play.
Controls: Firm, finger-ready
Finish: Facia Panel: Photo-etched
Box: Steel, grey hammer tone enamel.
Dimensions: 8 in.×3¾ in.×3 in. (20.3 cm.×8.4 cm.×7.6 cm.).
Weight: 32 ozs. (0.9 kilos).

POSTERS FOR PHYSICS CLASSES

The W. M. Welch Manufacturing Company has put up a beautiful set of posters for the physics room. These may be obtained free of charge by writing W. M. Welch Manufacturing Company, 1515 Sedgwick Street, Chicago 10, Illinois. A good picture is an excellent teacher.

RECREATIONAL MATHEMATICS FOR THE MATHEMATICS CLASSROOMS OF OUR SECONDARY SCHOOLS

LOUIS GRANT BRANDES
Encinal High School, Alameda, Calif.

"Recreational mathematics items tend to throw more life and informality into what might otherwise become a formal and drab subject. All of my pupils 'go for it.'"

"I have found that children carry the interest home that was stimulated by recreational mathematics in the classroom; they frequently bring similar materials into the classroom from their homes. I feel this is an excellent public relations medium for our school."

"It helps to let pupils know that a mathematics teacher is a human normal individual."

These are remarks from secondary school mathematics teachers that have made use of recreational mathematics items in their classrooms.[1]

Lending support to the above comments are two experimental-control studies carried out to determine the effect of using recreational mathematics on pupils in mathematics classes.[2] In each case where recreational mathematics was presented to an experimental group and withheld from a control group, marked differences in achievement, as measured by standardized tests, were in favor of the experimental group.

In view of this evidence it would seem that those teachers that are not now making use of recreational mathematics materials with their classes might well consider the possibilities of so doing.

EXAMPLES OF RECREATIONAL MATHEMATICS ITEMS

Included in the recreational mathematics interest areas that can be used successfully with secondary school children are four interest areas as follows: Facts and stories, linkages, problem, and optical illusions. These interest areas will be briefly discussed and illustrated on this and the following pages.

Facts and Stories. Pupils attending mathematics classes have the right to expect their teachers to have a sense of humor. A "goodly" supply of mathematical facts and stories, that can be presented at

[1] Brandes, L. G., "Recreational Mathematics Materials in the Classroom," *The California Journal of Secondary Education*, Vol. 28, No. 1, January, 1953, pp. 51–55

[2] Porter, R. E., "The Effect of Recreations in the Teaching of Mathematics," *School Review*, June, 1938, pp. 423–427.

Brandes, L. G., "Math. Can Be Fun: Tricks, Puzzles, Wrinkles Raise Grades," *The Clearing House*, Vol. 25, No. 2, October, 1950, pp. 75–79.

opportune times, makes any teacher a better teacher. Materials that may be included under this topic are mathematical stories, jokes, interesting facts, and historical facts. Several "interesting facts" and a mathematical story are offered as examples of materials included under this topic.

Mathematical stories, when synchronized with subject material as a part of a lesson plan, can provide valuable assistance in emphasizing certain points of a lesson. Mathematical concepts can be "driven home" by the teacher that has a story ready with which to emphasize the answers to questions their pupils ask. Stories can be used to illustrate common errors of addition, subtraction, multiplication, and division; the concepts of raising a number to a power, the size of large numbers, the capacities of volumes, etc., can be much more readily developed when a number of interesting facts are available to serve as illustrations.

Examples of Facts and Stories:

Some Interesting Facts

A sheet of notebook paper is approximately .003 of an inch thick. Suppose it were possible to tear the sheet of paper in half and place the two pieces together, one on top of the other, then tear them in half again and place the four pieces together in a pile, then tear them in half a third time and place the eight pieces in a pile, and so on until the paper had been halved fifty times. If it were possible to carry out this process, how high would you guess the final pile to be? Some persons say a foot high, others venture several feet, a few throw all caution to the wind and say a mile, but nearly all refuse to believe the pile would be over *fifty million miles high.*

Did you know that a million seconds equal 11.6 days, that a million minutes equal 1.9 years, that a million inches equal 15.7 miles, and that a million feet equal 189.4 miles? Did you know that a million pennies would make a stack almost a mile high, that a million one dollar bills would weigh over 2,000 pounds, and that a million dollars would buy 100 homes costing $10,000 each?

Did you know that the total population of the world is approximately 2,200,000,000 people? Considering the size of the average person to be six feet tall, one foot thick, and one and a half feet wide (more than twice the volume of the average person), it would be possible to place the entire population of the world in a coffin less than one-half mile cube.

A Story about Pat and Mike

Pat and Mike decided to go into the ice and coal business. They did fine with their ice business, because everyone had the correct change. However, when it came time to send out their first coal bill, they were a little undecided about the amounts to be billed. The following conversation was overheard:

"Seven tons of coal at thirteen dollars a ton," said Pat, "that will be twenty-eight dollars."

"How do you figure that?" asked Mike.

"Easy!" replied Pat. "Look! Thirteen dollars times seven; seven times three is twenty-one, seven times one is seven; twenty-one and seven are twenty-eight; twenty-eight dollars."

"I'd better check it," said Mike. "If I divide twenty-eight dollars by seven and get thirteen dollars, I'll know you're right. Let's see now, twenty-eight dollars divided by seven; seven goes into eight one time with one left over; bring down the two to make it twenty-one; seven goes into twenty-one three times. That's thirteen dollars, so I guess you're right."

"We'd better check it once more to be sure," said Pat. "I'll write down thirteen dollars seven times and you add it. That way we'll know we're right."

"OK," replied Mike. "Three, six, nine, twelve, fifteen, eighteen, twenty-one, (adding the left column), twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight; twenty-eight dollars. . . . It checks!"

So they sent a bill for $28.

	$13	
	7	
	21	
	7	
	$28	
7/$28		$13
	7	
	21	
	21	
	$13	
	13	
	13	
	13	
	13	
	13	
	13	
	$28	

Linkages. A number of linkages may be constructed which illustrate important, as well as entertaining, mathematical principles. The construction of these linkages may be undertaken as pupil projects or class projects, thus providing enjoyable workshop activity either within or outside the classroom. The building of linkages and such other devices as can be used effectively in the mathematics classroom provides an opportunity for mathematics teachers and shop teachers to work together in establishing some of the fundamental mathematics concepts.

Such linkages include the "golden section" linkage, the bisector linkage, the trisector linkage, and the pantograph. Perhaps the easiest linkage to construct is the "golden section" linkage. This is illustrated in the example that follows.

Example of a Linkage:

THE "GOLDEN SECTION" LINKAGE

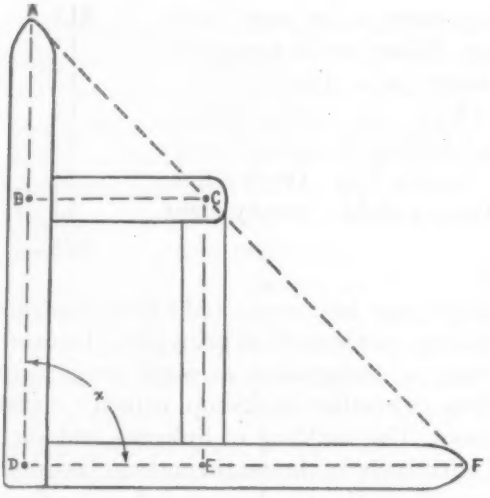
Several thousand years ago the Greeks became very interested in a mathematical relationship that they called the "golden section." It consists of the division of a segment into a mean and extreme ratio. The numerical value of the ratio has been found to be approximately .618. This means that one part of the segment is about .618 its entire length.

This ratio has been found to provide the most pleasing two dimensional figure. As a result the rectangle whose width is .618 its length is frequently used in the design of rectangular objects.

A spiral determined by a further division of a "golden section" rectangle according to the "golden section" ratio is found frequently in nature. It is found in the arrangement of seeds in flowers, the shells of snails and other animals, certain rock formations, the arrangement of leaves on the stems of plants, etc. Frequently it is used in designs and artistic relationships.

The "golden section" ratio is frequently found in the comparison of lengths that occur in nature, such as the distance from the forehead to the nose and from the nose to the chin of a person, the distance from the bill of a bird to its legs and from its legs to the end of its tail, the distances between the joints of the fingers, etc.

The diagram below provides the data from which a linkage device may be constructed for comparing various lengths to the "golden section" ratio. The linkage may be made out of metal or wooden strips.



$AB = 3.82''$
$BD = 6.18''$
$BC = 3.82''$
$DE = 3.82''$
$EF = 6.18''$
$CE = 6.18''$
$AD = 10''$
$DF = 10''$

For any angle x, the distances from A to C and from C to F will conform to the "golden section" ratio.

After constructing the linkage, measure the following items for comparison to the "golden section" ratio: The length and width of books, the length and width of other rectangular objects, the joints of the fingers, the features of a person's face, and the length and width of a sheet of paper. After making these comparisons it is interesting to look for other items that conform to the "golden section" ratio.

Problems. Recreational problems are the most common form of recreational mathematics used in the classroom. Perhaps this is be-

cause problems are the most common type of recreational item available in resource books and because problems lend themselves most readily to the formality of many mathematics classrooms. Certainly the possibility of using recreational problems in the classroom for the enrichment of the mathematics subjects should not be overlooked. Problems can be presented to classroom pupils in many ways. Means of presentation include: Placing items on the chalk board as motivating problems, assigning problems at the seats of selected pupils as "honor" problems, and offering items as a part of a homework assignment.

The presentation of recreational problems might also be considered under the heading of public relations. Items assigned in the mathematics classroom will usually reach mom and dad. Such items can provide an opportunity to develop a warm relationship between parents and the mathematics teacher; they can assist in getting the parents interested in the mathematics subjects and in the school.

A number of recreational problems of varying difficulties are presented in the examples that follow.

Examples of Recreational Problems:

SOME NUTS TO CRACK

1. Two friends had an eight-quart jug of cider that they wish to share equally. They had two empty jars, one holding five quarts, the other holding three quarts. They were able to divide the cider equally without so much as spilling a drop. Can you figure out how they were able to do it?
2. A snail, climbing up a pole thirty feet tall, ascended three feet each day and sliped back two feet each night. How long did it take the snail to reach the top of the pole?
3. If it takes eight seconds for a clock to strike eight o'clock, how long will it take the same clock to strike twelve o'clock?
4. If a watch is stopped for fifteen minutes every hour, how long will it take the hands of the watch to go from twelve o'clock noon to twelve o'clock midnight?
5. On a round trip between two towns twenty miles apart a bus averaged 40 miles an hour one way and 60 miles an hour the other. What was the average speed of the bus for the round trip?
6. Assume the earth to be a perfect sphere 25,000 miles in circumference. Also assume that a wire could be stretched tightly around the equator. Suppose we could cut this wire and add another piece of wire exactly 100 feet long. If the wire, including the link, could now be held an equal distance from the earth's surface at all points, could a man (a) get his finger under it, (b) step over it, (c) jump over it, or (d) walk under it?
7. Three men, arriving late at a hotel, were charged twenty dollars apiece for a room, or a total of sixty dollars. Later the hotel clerk, thinking this sum exorbitant, decided to refund ten dollars of the money to the men. He sent the money by a bell boy who observed that the ten dollars could not be equally divided among three persons. Thus, the bell boy kept four dollars for himself and returned six dollars to the men, two dollars apiece. Upon the return of the six dollars, the room cost each man eighteen dollars, or a total of fifty-four dol-

ars. However, if the bell boy had only four dollars, what became of the other two dollars?

8. A man made a deposit of seventy-five dollars in a bank. He made the following withdrawals and had the following balances left after each withdrawal:

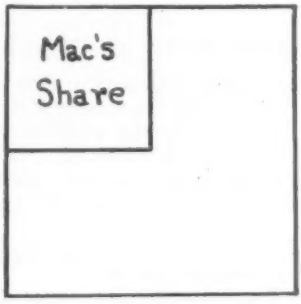
First withdrawal:.....	$40.00	Balance:.....	$35.00
Second withdrawal:.....	15.00	Balance:.....	20.00
Third withdrawal:.....	5.00	Balance:.....	15.00
Fourth withdrawal:.....	9.00	Balance:.....	6.00
Fifth withdrawal:.....	6.00	Balance:.....	0.00

Why is there a difference of one dollar in the totals? Can you account for it?

9. There are three men, Tom, Dick, and Harry, each of whom is engaged in two occupations. The occupations are as follows: bootlegger, musician, painter, chauffeur, barber, and gardener. From the following facts see if you can find the two occupations of each man:

1. The painter bought a quart of spirits from the bootlegger.
2. The chauffeur offended the musician by laughing at his mustache.
3. The chauffeur courted the painter's sister.
4. Both the musician and the gardener often went hunting with Tom.
5. Harry beat both Dick and the painter at checkers.
6. Dick owed the gardener ten dollars.

10. Mac, a ship's cook, baked himself a birthday cake. Four of his pals immediately demanded a share. "OK," said the wily Mac as he cut out a quarter for himself, "the rest is yours . . . if you can cut it such that all four pieces are exactly the same size and shape." The boys got their cake without making a single diagonal cut. See if you can determine how it was done.



Optical Illusions. It has been said that "people like to be fooled." This applies to children in a classroom as well as a radio, television, or theatre audience. The topic of optical illusions provides materials whereby classroom pupils can not only have an enjoyable time being "fooled" but can also learn something about mathematics. The children can learn how not to be fooled by the application of certain mathematical principles. The importance that optical illusions play in the design of clothing, the camouflage of military objects, the architectural plans of buildings, and many other relationships should provide information both of interest and value to pupils.

Optical illusions can be presented to mathematics classes in a number of ways: (1) By presenting a number of illusions as a recreational quiz and following the quiz by a general discussion, (2) as a lec-

ture, with illustrations from slides, film strips, and/or pictures, or (3) by "working in" materials as an integral part of class assignments (such as in geometry classes).

If sufficient interest of pupils is aroused, specific types of illusions may be studied. Pupils may wish to make a collection of illusions; some pupils may construct illusions of "their own." It may be of interest to the children to classify illusions according to types. Types of illusions include illusions of contrast, illusions of interrupted extent, height-width illusions, and others.

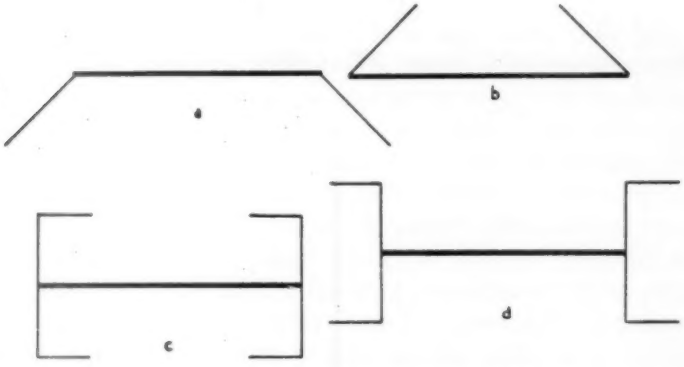
Examples of Optical Illusions:

IS SEEING WORTH BELIEVING?

Take this opportunity 2 C if "seeing is believing" by answering the five following questions. You should observe the following rules: (1) Select the response that you think is correct and write it in the space provided. (2) Do not measure any of the figures with a measuring instrument; use your eyes only. (3). Record your honest opinion.

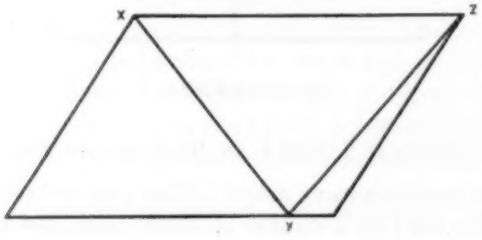
1. One of the "heavy" lines below is longer than any of the others. Which one do you think it is?

Answer: _____



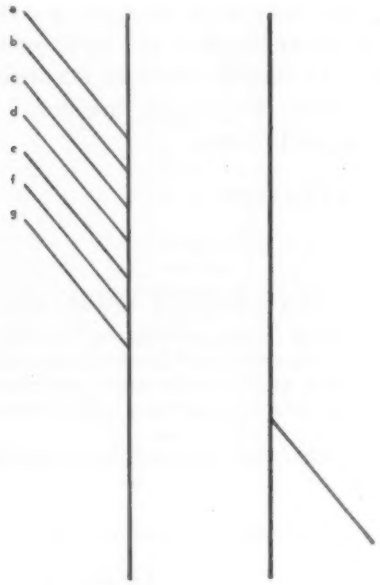
2. Which of the segments below is the longer: XY or YZ?

Answer: _____



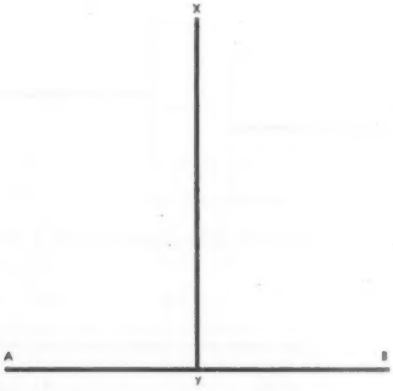
3. One of the segments on the left appears to be extended. Can you tell which one it is?

Answer: _____



4. Which segment is the longer: XY or AB?

Answer: _____



See next page for 5

How Recreational Items Can Be Used in the Classroom

A number of teachers have asked, "Can you tell us where different items should be used in a course of study and just how such items

5. Which circle is the larger: The center circle in Fig. A or the center circle in Fig. B?

Answer: _____

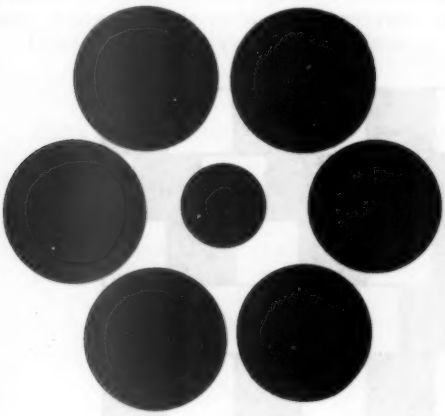


Fig. A

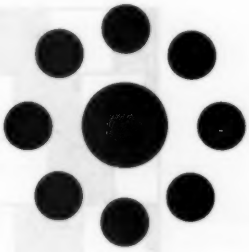


Fig. B

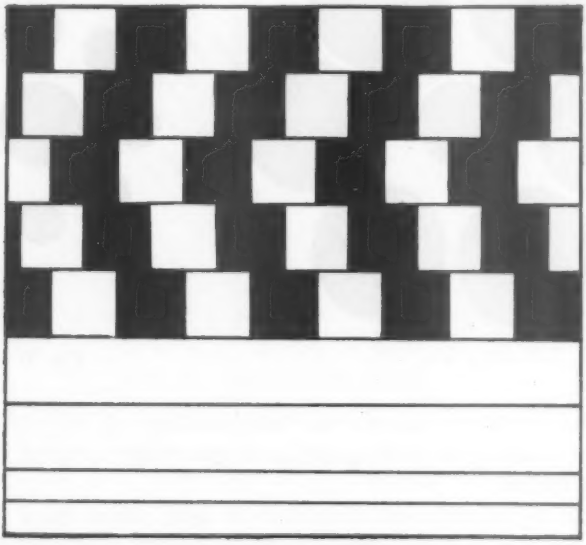
can serve as teaching aids in the presentation of subject matter?" Perhaps the answer to this question is partially covered by the remarks that follow.

Individual teachers could report how and when they have used specific items successfully with pupils, and it could be assumed that other teachers could make similar use of the items with equal success. Teachers, however, like their pupils, are individuals with different personalities, attitudes, and abilities. The uses that teachers find for recreational items are likely to be quite different. Similarly, two or more sections of a subject, due to the many differences of the members, may vary greatly in their ability to "move" through subject content; the use that could be made of recreational items with such sections might vary considerably. Nor is it reasonable to believe that specific items are useful solely with specific units of a subject; an item that proves useful to illustrate a point in general mathematics may also prove useful to illustrate another point in algebra or geometry. Thus, it seems logical to assume that recreational items can best serve teachers as resource materials whose usefulness is limited by the resourcefulness and ingenuity of the individual teacher.

Teachers have indicated some of the ways in which they have made use of recreational items.[3] Asked how they used recreational mathematics materials in teaching their classes, a selected group of teachers indicated as follows: Present materials to classes as a part of a daily

[3] Brandes, L. G., "Using Recreational Mathematics Materials in the Classroom," *The Mathematics Teacher*, Vol. 46, No. 5, May, 1953, pp. 326–330.

An Illusion of Contrast. Contrasting colors, as well as contrasting surroundings, often produce interesting results. Color contrasts are frequently used during wartime to camouflage the shape and position of objects. When observed from a distance it is very difficult to establish the direction in which a well camouflaged ship is travelling. Notice in the figure below how the parallel lines, bordered by black and white squares, seem to converge. A pair of straight-edges placed along these lines may be necessary to establish that they are really parallel.



lesson plan; give items to individuals and small groups of a class to stimulate interest in a lesson; offer materials to individual pupils that have completed their assignments; give materials to pupils to work on outside of class; place items on the chalk board before classes assemble to gain the attention of pupils; place items on classroom bulletin boards and change at regular intervals; present materials during "fill in" time, usually at the end of a period; and present items to classes on special days, such as days before school holidays and visiting days. Other ways these teachers reported using recreational mathematics materials include: Presentations for recreational and group meetings, items for school paper, items for school bulletin boards to stimulate interest of pupils not enrolled in mathematics classes, materials for mathematics club activities, and materials for rainy day sessions.

Summary

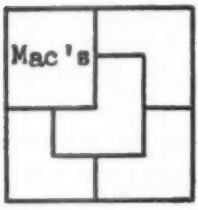
There is evidence to indicate that recreational mathematics can be used to increase interest and achievement in the secondary school mathematics subjects. Recreational mathematics materials may be classified into a number of interest areas that include items that can

be used as teaching aids as well as for stimulating interest. These recreational items can serve teachers as resource materials that may be used in a variety of ways.

ANSWERS

SOME NUTS TO CRACK:

1. There are a number of possible solutions; left to reader.
2. 28 days.
3. 12 4/7 seconds.
4. 15 hours.
5. 48 mph.
6. He could walk under it easily. It would be 15 ft. 9 in. high. Answer is (d)
7. Bookkeeping! Example of invalid thinking.
8. There is no reason that the two columns should be assumed to be equal.
9. Tom, painter and baker; Dick, bootlegger and musician; Harry, gardener and chauffeur.
10.



IS SEEING WORTH BELIEVING:

1. *b*.
2. *YZ*.
3. *d*.
4. *AB*.
5. They are the same size.

Note: If answers seem to be wrong, use a divider to validate them.

Note concerning recreational materials: No credit is taken for the originality of any one or more of the items; nor is any credit given for their originality, as it is doubtful that the origin of many of the items could be traced to any particular person. On the other hand, none of the items have been purposely "lifted" from any known publication.

NEW VIRUS HITS DOGS' BRAIN AND NERVOUS SYSTEM

A new disease threat to dogs has been discovered. It is a virus disease that attacks the brain and nervous system.

Continuous high fever and later trembling, weakness, failure of muscular co-ordination, disturbed reflexes and epileptic-like convulsions are the symptoms.

The disease was discovered by Dr. James H. Whittem of the University of Sydney, Australia, in a four-month-old fox terrier. This terrier died of the disease. It had had shots against distemper one month before. Study of its body led to discovery of what Dr. Whittem believes is a new virus distinct from others that cause canine encephalitis. He reports his findings to the scientific journal, *Nature*.

HOW MUCH? A MATHEMATICS PLAYLET

KENNETH P. KIDD
College of Education, University of Florida, Gainesville, Fla.

This playlet depicts how man from the earliest times passed through certain steps in the development of ways to answer the question, "How much?" This development begins with early cave man's ingenious invention of measure to the latest coordinated efforts of present day civilization to devise the most effective system of weights and measures.

Scene I. Early Man Devises His First Unit of Measure [Narrator reads, giving plenty of time for the characters to act. Cardboard with the title of the scene may be placed on the stage.]

Narrator: The first scene take place somewhere in very early times. Cavemen Ug and Og meet. Ug shows Og his new spear and tells Og how he used it to kill four tigers. [Ug and Og should be about the same size. They meet and exchange grunts. Ug carries a spear which should be about nine feet long. Ug lifts his spear up and balances it as if he was ready to throw it at a tiger, calling Og's attention to it with grunts and gestures. Ug then slaps himself on chest boastfully as he tells—in grunts—of the four tigers killed.] Og shows interest in the length of Ug's spear since his arms are about the same length as Ug's. Og wants to use it to kill tigers since he needs some tiger skins. [Og grunts and gestures as he starts to walk away with the spear.] Ug doesn't want to let Og borrow the spear and suggests that he go into the woods, cut down a small tree, and make himself a spear the same length as his spear. [Ug grasps Og's arm and grunts and points to the woods.] Ug tells him that he must be going and can't let Og take the spear into the woods to hunt for a sapling.

Narrator: Og tries to see if he can mark off on his body the length of the spear but finds that it is longer than his height or his reach. [Og looks at spear, stands it by himself and tries to reach the top, and picks it up and tries to reach the length with both arms outstretched.] Ug calls Og's attention to a grape vine hanging in a nearby tree and suggests to Og that he cut off a length of the grape vine equal to that of the spear and carry this length with him. [Ug grunts, points into a tree and at spear.] Og can't reach the vine. [Og jumps.] He has a problem now. Let's see how he solves it. [Og is puzzled. He scratches

his head. While holding his arms in front of his face, he gets an idea.] Og gets an idea. He will use his forearm, seeing how many times this length is contained in the length of the spear. He picks up a pebble each time he places his forearm down. There goes Og into the woods with his pebbles and, of course, with his forearms, which are certainly convenient.

Narrator: This length of the forearm was called the cubit and was used for thousands of years. We have heard it said that "necessity is the mother of invention." Prior to this time all measuring was done by the process of fitting. Since Ug would not let Og borrow his spear in order to cut a sapling the same length, it was necessary for Og to devise another way of getting a sapling the desired length. This way is that of applying an arbitrary length—called a unit—to the length to be "measured."

Scene II. The Need for Standardization

Narrator: Most of our units of measurement of length are based upon measurement of parts of the body. The hand [Shows width of palm of hand], the span [Shows fingers outstretched on a hand], the cubit, the yard [Indicates distance from nose to tip of fingers on outstretched arm], and the fathom were all in common use. The fathom is the distance from tip of fingers to tip of fingers on outstretched arms and comes from a word meaning "to embrace."

Narrator: Each man of course carried his units around with him at all times. But since people's body measurements differ widely, disputes were quite frequent. Let us look in on an open market operated by Nol and Sud in early times. Ahab comes in to buy rope.

[Nol should have a *very* short fathom while Ahab and Sud should have *very* long arms. Sud might have a crude abacus with pebbles placed in grooves on a board.]

Nol: Come in, Ahab. What can we do for you?

Ahab: Nol, I want some good strong rope. What do you have?

Nol: We have some of the finest rope. [Hands ball of rope to Ahab.]

Ahab: [After testing rope] How many fathoms of this rope will you trade me for a fat young lamb?

Nol: We will trade you 10 fathoms for a lamb.

Ahab: I guess that's fair enough.

[Nol measures off 10 fathoms, using his short forearms. Ahab looks skeptically at the length of rope and measures on his extra long arm, finding the measure to be only 8 of his fathoms.]

Ahab: Now look here, Nol. When I said 10 fathoms, I meant 10 of my fathoms. There are only 8.

Sud: Ahab, Nol has been measuring and selling rope here for some time. If you are not satisfied with this rope, then let's call our chief in and let him measure the rope.

Ahab: Call in the chief.

[Nol brings in the chief.]

Nol: Chief, will you measure this rope? Ahab thinks he is not being given full measure.

Chief: Let me settle the dispute. [He measures.] There are 9 fathoms here. What's the dispute, Ahab?

Ahab: I was supposed to get 10 fathoms, but I measured only 8 of them.

Chief: Let's look at these arms. [Compares Ahab's and Nol's fathoms.] Ah! No wonder there is a dispute. But Sud's arms are long. Nol, why don't you let Sud measure the rope? He has much longer arms than you?

Sud: I go out and buy the rope and Nol sells it! [Group laughs.]

Chief: This matter will require a royal decree. I don't want to be called every time Nol wants to measure rope, so I will measure off a royal fathom. [Proceeds to do so.] This will henceforth be a fathom among all people of our tribe. Peace unto you.

[Chief leaves. Nol measures off 10 fathoms with the standard. Ahab leaves. Nol hangs the standard up in view.]

Narrator: Thus one tribe made steps toward standardization of its units of measure. At first the lengths of a unit of measurement varied greatly also from tribe to tribe. However, the desire to trade between groups of people caused people to see the value of further standardization. As groups joined together one length for a unit displaced several lengths which several groups separately used.

Scene III. Some Familiar Units

Narrator: In Scene III you will witness three instances illustrating the early use of units of measurement.

Narrator: From I Samuel 17:4 we read, "And there went out a champion out of the Philistines named Goliath of Gath, whose height was six cubits and a span." [If possible,

have a tall boy walk in on stilts. Let someone mark off his height onto a pole, and putting the pole in a horizontal position, proceed to show that his height is as described.] One cubit, two cubits . . . 6 cubits and 1 span over. [Narrator counts as the pole is being measured.]

Narrator: From Genesis 6:15 we find the dimensions of Noah's Ark. The length was 300 cubits. Since the length of the Hebrew forearm was about $1\frac{1}{2}$ feet, the Ark was about 450 feet long or about $1\frac{1}{2}$ times the length of a football field between goal lines. The width of the Ark was 50 cubits or $\frac{1}{4}$ the length of a football field. The height of the Ark was 30 cubits.

[A group of soldiers assemble and start marching with one person counting the paces: "unus, duo, tres, quattuor, quinque, sex, septem, octo, novem, decem, undecim, duodecim, tredecim, quattuordecim. . . ."]

Narrator: We have just now seen a group of Roman soldiers counting the number of paces or double steps from Rome. The Roman unit of measurement of distances was a mille passuum, which meant a thousand paces. Our word "mile" comes from "mille." Since a double step is about 5 of our feet, the Roman mile was about 5000 feet.

Narrator: We are going to be interrupted. These two men are disputing the length of a rod. [Two men, each with a pole, one being 17 feet long and the other about 14 feet long, appear on stage, compare poles, and gesticulate as if in argument.] But I believe this other gentleman will help them settle their dispute.

Town Crier: [Enters and reads loudly from official document] Hear ye! The King decrees: If two men dispute the length of a rod, the two shall stay the first sixteen men who leave the church, be they thick or be they thin, and take the length from the toe of the first to the heel of the last. That shall be the proper rod. [He departs.]

Narrator: Here comes a group out of a church building now. The two in argument proceed to line up sixteen of them and mark the distance on a pole. They have settled their argument. [All leave.]

Scene IV. Establishment of the Metric System

Narrator: The fourth scene deals with the establishment of the metric system of measurement by France. Let us look in on a meeting of the Academy of Science of Paris

on March 19, 1791. You will notice 5 scientists who are members of a committee reporting to the larger assembly

First Scientist: [Addressing larger assembly] Distinguished members of the Academy of Science, our committee has been studying the possibility of bringing some order out of the chaos of our weights and measures. We predict succeeding generations will look back upon this meeting as a memorable one if we can make some decisions that simplify our system. We shall now be brought up to date on what decisions were reached last Fall.

Second Scientist: Fellow members of the Academy, let us first glance at the chaotic systems used in France and England. [He reads from the following cards:]

France
12 pouets = 1 lignes
12 lignes = 1 pouce
12 pouce = 1 pied
6 pieds = 1 toise

England	
3 barley-corns	= 1 inch
12 inches	= 1 foot
3 feet	= 1 yard
5½ yards	= 1 perch (rod)
40 perches	= 1 furlong

We all realize how inconvenient it is to work with these units when we are required to multiply or divide by that number *12*, which we borrowed from the *Romans!* And the English system is much worse than ours. We have not yet decided upon a unit of length but whatever it is the decision has been reached that we will subdivide it into 10, 100, and 1000 parts and also define units which are 10, 100, and 1000 times our basic one. The Royal Society of London has been urged to cooperate with us in this revolutionary undertaking. Some of you have cautioned me that we cannot expect the people of France to discard a system which they have lived with all of their lives. But may I remind you that because of the Revolution it will be possible to gain public consideration for radical ideas in science as well as in government! [Group applauds.]

First Scientist: Messieurs, our problem today is to decide upon the unit of measures. What proposals do we have?

Third Scientist: [Showing a string about 40″ long with a weight on one end.] I have in my hand a seconds pendulum—meaning that it requires one second for it to make one swing. You will agree that its length is a convenient unit to use. I submit this as the meter and suggest that we proceed

to determine its value with great, great accuracy at sea level at 45° latitude. [Groups talk among themselves with the majority giving nods of disapproval.]

Fourth Scientist: Messieurs, may I propose that we base our unit upon the measurement of the earth's equator. [Groups chat again with sentiment about equally divided.]

Fifth Scientist: As you well know, the length of a seconds pendulum will vary slightly as we vary our distance from the center of the earth. [Several heads shake approvingly of point made.] And also the measurement of the earth's equator will be extremely difficult. [Looks at globe.] The land masses of South America, Africa, and Borneo traversed by the equator are regions unexplored and inhabited by wild animals and savages. Certainly we must reject this proposal also.

I would, however, like to make a third proposal. Let us base our meter upon the distance from the equator to the North Pole. Here is Barcelona, Spain. And here on the same meridian is Dunkerque, France. This is the greatest meridinal distance available for measurement in all Europe. You may recall that Monsieur Lacaille in 1740 surveyed this distance. From his recorded data we can compute the total distance from the equator to the North Pole. One ten-millionth of this distance would provide us with a tentative standard until we re-survey the distance with the greatest accuracy possible. [The whole assembly rises applauding. Group exits.]

Narrator: The Academy of Science of Paris adopted the proposal to base the system of measurement on the length of the earth's quadrant. The French surveyors set to work on the vast labor of measuring the distance from Barcelona to Dunkerque. After a few years they completed the task and arrived at a unit of length which is a little more than our yard. This unit was called a meter [displays meter bar] after the French word for "measure." Other countries joined France so that today 75% of the civilized world uses this metric system. It is used today for international events—Olympic races, baggage weight allowance for air flights to other countries, etc. Even though the metric system is not used widely for trade in this country, it is *the official unit of measurement.* Our meter bar is kept in the Bureau of Standards in Washington, D. C. Sacred relics of these standard meter bars are also kept in an underground shrine at Sèvres near Paris.

In September 1953 a ten-nation advisory committee met in Sèvres, France and recommended that these hallowed meter bars be abandoned. The measurement of the earth's quadrant was in error! In 1954 a full-dress international conference will make a decision. Proposals will be made to define the meter in terms of wave lengths of light. Germany wants to use light given off by a krypton isotope; Russia wants to use cadmium 114; the United States scientists prefer mercury 198. We shall see.

OVERSEAS BATTLES COMING TO WHITE HOUSE TV SCREEN

The President in the White House and high military officials in the Pentagon will be able some day to watch on television the actual progress of battles as they occur in far-off corners of the earth.

This was indicated during a demonstration here of combat television that has been developed by the U. S. Army Signal Corps and the Radio Corporation of America. All combat TV needs today to bring battle progress into the strategic command centers and the nation's capital is a method of carrying TV signals across the ocean and the electronics industry is working on that. Thus, large scale invasions or A-bomb or H-bomb strikes may be watched during the instant they are happening. As a result of what appears on the TV screen in the Pentagon or the White House, plans can be changed and new orders sent to the front.

A distinguished audience including Gen. Matthew Ridgway, Army Chief of Staff, and Brig. Gen. David Sarnoff, chairman of the Board of R.C.A., watched the demonstration of combat TV here. They were guests of the Second Army. The Third Armored Cavalry Regiment staged a river crossing and hill assault under mock combat conditions to demonstrate how commanders could use TV. Seven hand-carried TV cameras, one mounted in an Army plane and another on an amphibious assault craft, actually went into battle with the troops. They brought to the battle commander's post instant pictures of what was going on. These allowed him to redirect his troops and order additional artillery fire as needed. He interviewed a captured "prisoner" through the medium of TV and thus gathered valuable information about the "enemy."

The equipment used in the demonstration was part of the Signal Corps Interim Tactical TV System devised for use on the battlefield.

POLAROID RADIATION DETECTOR

Edwin H. Land, inventor of the one-minute Polaroid-Land camera, added another patient to his files. It covers a mouth-held device which tells the user how much atomic radiation he has absorbed.

Designed for use in experimental laboratories, the device consists of a photographic film sensitive to X-rays, radium, uranium and other natural or artificial radioactive materials, particularly deadly gamma radiation, beta radiation and neutron radiation.

This film is carried in a badge. When the user wants to know the degree of radiation he has absorbed, he slips it into his mouth, crushes a capsule sandwiched in the circular film packet, permits the developer to work on the film and then examines the film for his answer. Holding the film in his mouth while it is being developed eliminates the effect of varying laboratory temperatures. The film thus will always be developed at body temperature.

Mr. Land assigned patent No. 2,687,478 to the Polaroid Corporation.

CORRELATION OF HENMON-NELSON TESTS OF MENTAL ABILITY WITH THE NATIONAL ACHIEVEMENT GENERAL SCIENCE TEST

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The purpose of this study was to determine the extent of correlation between the Henmon-Nelson Tests of Mental Ability and scores on the National Achievement General Science Test.

PROCEDURE

The one hundred and thirty-four freshman students enrolled at Southern University during the summer session of 1953 comprise the scope of this study. The Henmon-Nelson Tests of Mental Ability—Form A, and the National Achievement General Science Test were administered to seventy-five female and fifty-nine male freshman students.[1] The test scores, obtained from the general science test, were correlated with the Intelligence Quotient already determined for each student.

RESULTS

The scores on the National Achievement General Science Test ranged from 14 to 95, and the Intelligence Quotient ranged from 59 to 136. Table I shows that the male students made the higher scores on the general science test, and the female students had the higher I.Q. The mean for the females on the general science test was 47.5, and for the males, 49.1.

TABLE I. GENERAL SCIENCE SCORES AND INTELLIGENCE QUOTIENTS OF MALE AND FEMALE STUDENTS BY RANGE AND NUMBER

Male Students				Female Students			
Score Range on General Science Test	Number	Range of I.Q.	Number	Score Range on General Science Test	Number	Range of I.Q.	Number
80–95	5	90–110	5	80–87	1	136	1
70–79	3	85–105	3	70–79	2	100–103	2
60–69	5	92–123	5	60–69	10	82–123	10
50–59	9	72–105	9	50–59	18	80–110	18
40–49	20	70–111	20	40–49	24	68–109	24
30–39	12	65– 96	12	30–39	14	68– 90	14
23–29	5	66– 97	5	14–29	6	59– 76	6

[1] There is no particular significance in breaking down the students into male and female except as they refer to the data contained in Table I of this study.

The method used for computing the coefficient of correlation was the Pearson product-moment method. The correlation between the scores on the National Achievement General Science Test and the Intelligence Quotient for the entire group was .645.

Findings and Conclusions

1. The data included in Table I would seem to indicate a trend that the students who made high scores on the General Science Test also had high IQs, and students with low scores on the test had low IQs.

2. There were a number of students with high IQs and low scores on the general science test. This suggests that these students have the mental ability to do well on the test, but probably have not been exposed to the necessary information found in general science.

3. The correlation between the National Achievement General Science Test and the Henmon-Nelson Tests of Mental Ability of .645 is significant. It appears that predictions for probabilities of certain scores on the general science test may be made on the basis of the student's IQ.

4. From the correlation, it seems that the test requires the same mental ability as the IQ.

For practical purposes, it is the writer's conclusion that students with high IQs have the ability to do well on the general science test. Students with the high IQs and high scores on the test indicate probabilities of being successful in the physical science course taught by the writer.[2] Students with high IQs and low scores on the general science test would seem to indicate that the general science courses taken by them on the high school level did not instill in them effective study habits. It is the writer's opinion that had effective courses been offered in high school, the student scores on the general science test would have been effectively improved by the students concerned in this study.

It seems that for the students who are deficient in subject-matter content in general science at the college level, a *good* course in physical science, as well as a *good* course in the biological sciences, would help to improve their academic performance in general.

[2] The physical science course taught by the writer is designed for general education. Important concepts and principles from Astronomy, Geology, Meteorology, Chemistry and Physics are included in the course.

The prosperity of a country depends, not on the abundance of its revenues, nor on the strength of its fortifications, nor on the beauty of its public buildings; but it consists in the number of its cultivated citizens, in its men of education, enlightenment and character.—Luther.

THE DEVELOPMENT OF A SYNTHETIC DETERGENT[1]

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The development of synthetic detergents as substitutes for soap is a modest chemical achievement of the past two decades. Of the variety of types which have found increasing general use in the home and special use in industry, the alkylarylsulfonate type is the one which is produced in largest volume. It is less complex chemically than some of the other types, and its similarities in structure and behavior to the soaps are readily apparent. It may serve, therefore, as an example for a discussion of the process of development of a synthetic product. The recounting of the story of the development of the alkylarylsulfonate type detergent is introduced with some examples of early research in chemistry, since this affords an opportunity to discuss some important general principles in scientific work.

FUNDAMENTAL RESEARCH

Benzene

The story begins with the chemistry of benzene. Coal had been used as a fuel for a long time. Some time about 1800 it was found that coal, if heated without burning, gave off a gas which could itself be burned. In 1825, Michael Faraday found that there was present in this gas a small amount of a liquid which he named benzene. Faraday gave a careful description of the new material, investigated a few of its chemical reactions, and found that it contained carbon and hydrogen, and so belonged to the class of organic compounds. The study of carbon and hydrogen compounds is now the special province of organic chemists, although such lines are not sharply drawn. The lines were non-existent in Faraday's time; he is perhaps more famed for his pioneering work in physics and physical chemistry.

Several of the chemists who soon afterward made benzene by other methods began to attack the problem of what, chemically speaking, is benzene. The first question arising in connection with its structure was the number of carbon atoms and hydrogen atoms the smallest particle of benzene contained. This was soon answered, thanks to the development at about the same time of methods for analyzing carbon and hydrogen compounds. It is necessary to find both the ratio of carbon to hydrogen, and also the total number of atoms in the molecule. Such methods indicated that there were six carbon atoms and six hydrogen atoms in a benzene molecule. That short statement, or rather the fact that is was possible to know not only that benzene

[1] Presented in part at the 124th Meeting of the American Chemical Society, Chicago, September, 1953.

contained carbon and hydrogen but how much of each, summarizes a great deal of chemical history prior to 1858. That date, just less than a century ago, is a clear mark in the transition to modern chemistry, and thus benzene is a good starting point for the discussion.

For many simple types of chemical compounds such information was sufficient for some understanding of structure, but for more complex chemical compounds it was interesting to find how the separate parts, the atoms, were arranged in space or bonded together. Note that the problem was interesting, but hardly of immediate practical importance. As a practical matter, benzene was recovered in quantity from coal gas and was used as a fuel, and even as a starting material for the first synthetic dye before the question of its structure was answered.

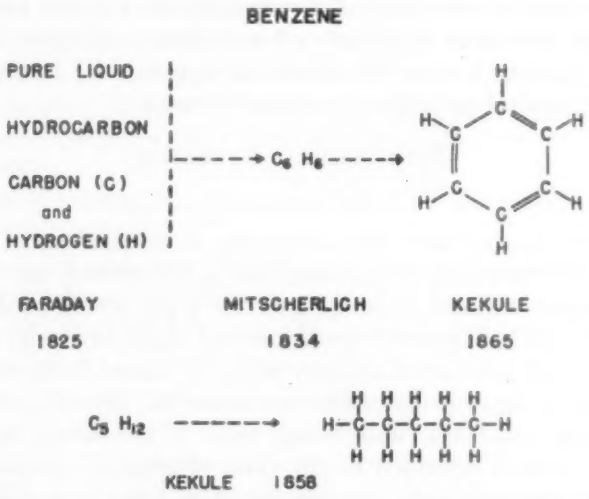


FIG. 1. Development of the constitution and structure of benzene.

This question was answered by the Kekulé theory of valence in 1859, one of the great advances of the type which explain or interpret previously observed facts. Kekulé first considered what was known about carbon and hydrogen compounds of simpler types. He proposed arrangements—chemical bonding—of carbon and hydrogen in compounds which explained neatly certain facts of chemical behavior that had been quite incomprehensible before. The idea that compounds might contain carbon atoms joined to each other in chains came first; his proposed structure for benzene followed after this theory had received some acceptance (Figure 1).

It is instructive to examine Kekulé's fanciful story of inspiration, which has been widely quoted or paraphrased, of the atoms joining into chains, in his dream, and of a snake-like chain catching its tail

to form a ring. His conclusion to this recital is more important advice: "If we learn to dream we shall perhaps discover truth. But let us beware of publishing our dreams until they have been tested by the waking consciousness." It is more instructive to examine the facts available to him, to read his publications, and to see how bold and brilliant a jump in chemical theory this was.

Kekulé's testing of his dreams by the waking consciousness meant, in practice, how well did his picture fit the observed facts of chemical behavior of benzene. It fitted well enough to be used, not without argument which has lasted almost up to this day, and not without some subsequent modification. That is true of most such theories—they are really a new point of departure for further work.

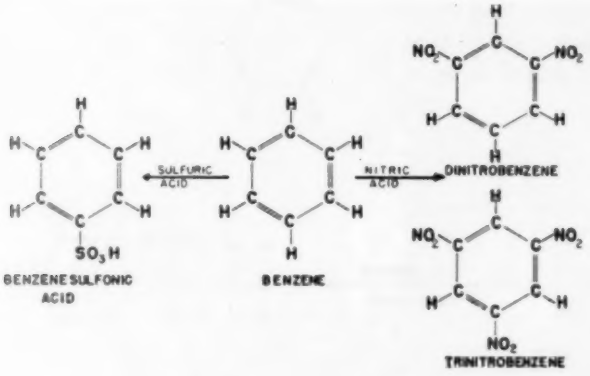


FIG. 2. Reactions of benzene.

Some of the chemical reactions of benzene discovered by mixing it with other chemicals, more or less at random to see what came out, resulted in the discovery of the compounds formed by reaction with nitric acid (Figure 2). Of these, trinitrobenzene and its relative, trinitrotoluene (TNT) are familiar as explosives. And by reaction with sulfuric acid, benzenesulfonic aid was formed. It was partly on the basis of clues from reactions like these that Kekulé was led to a satisfactory structural picture of benzene.

Friedel-Crafts Synthesis

Jumping ahead some twenty years, the next point for consideration is the work of an American, James Crafts, and a Frenchman, Charles Friedel, collaborating in Paris on reactions of aluminum chloride. This material, when free from water, was found to cause reactions between two other compounds which could not otherwise be made to combine. The techniques for handling materials free from water had first to be developed, of course. The reactions so brought about are

of the type illustrated in Figure 3. Friedel and Crafts began work along quite different lines—unexpected results led them to investigate the side path which led to the discovery of this type of reaction. The history of science is full of examples of the importance of side-paths. Fleming so discovered penicillin. Perfluoropolyethylene, a heat-resistant plastic material, was first formed by accident, when perfluoroethylene was stored inside a steel cylinder under pressure. When the valve was opened, the gas did not come out, as expected. The cylinder might have been thrown away, but the chemist, alert to the possibilities, looked further, cutting open the cylinder, and found the gas had changed into a solid.

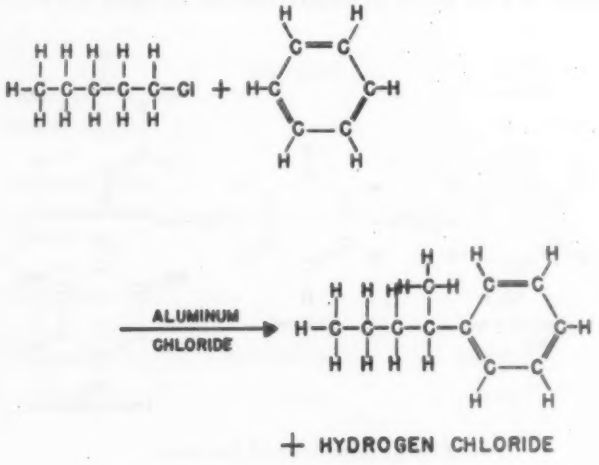


FIG. 3. Typical Friedel-Crafts reaction.

The importance of Friedel and Craft's work was not in the discovery of a new material, like benzene, or in the formation of a new concept, like Kekulé's structure theory of organic chemistry, but as a method for synthesizing, i.e., making many new compounds from simpler materials. As such, it is still much used, and a chemist conducting such a reaction in a modern laboratory uses equipment which is basically the same as that used by Friedel and Crafts, although it appears much different.

Many of the new compounds prepared by this reaction are of use as special fuels, solvents, and starting materials for further synthetic work, and it is therefore used in large scale work, particularly by the petroleum refineries. Petroleum refining is hardly a just description of the present work of that industry; the use of reactions of this type has changed the basis of work from that of a purely extractive industry to a synthetic organic chemical manufacturing one. The quantities of materials that Friedel and Crafts used might be multiplied by a

factor of one million, in estimating the quantity of material processed per hour in similar reactions in an alkylation unit such as that shown in Figure 4. The petroleum industry, using this and related reactions, is now a chief source of aromatic hydrocarbons such as benzene and, more particularly, the compounds closely related to it, since coal gas can not furnish enough.

We have been concerned, to this point, with a few developments in organic chemistry, and the types of work involved so far may be briefly reviewed. The early work described—what was the structure of organic compounds was the chief question—extended over fifty years. The contributions mentioned were those of one English, two German, one American and one French scientist. Not one of these,

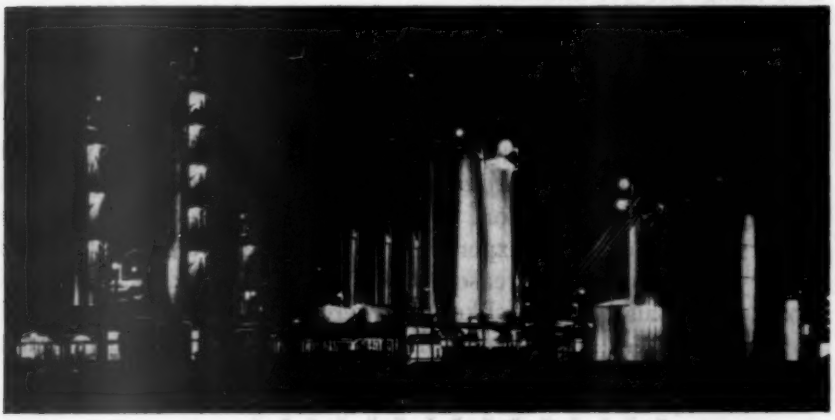


FIG. 4. Alkylation plant at night at Shell Oil Company's Wood River, Illinois, Refinery.

or all together, could have brought the story of the structure of benzene and its reactions to the point described; countless other scientists, working at the same time that they worked, or before, made essential contributions. The development of the practical arts of metal and glassworking, for example, was equally important in providing facilities and techniques for experimental work. A less obvious development, and one also deserving more discussion than can be included here, was the influence of the economic and social pattern of the times in encouraging such work. Those who worked on it either found the separate pieces of a jig-saw puzzle, or classified them, or put a few pieces of the picture together. There was little thought on the part of these men for practical applications, though practical applications were developed, as the result of other important scientific work, very soon afterward. The approach was that of finding what atoms were present in a complex compound, then how many of

each, then how they were put together—a physical picture of structure which was later confirmed and refined by measurements in the field of physical chemistry. The reactions, the synthesis of new materials, contributed to the fitting together of the picture, but they seemed to come so thick and fast, and to fit together so poorly, that Wöhler, one of the greatest practical and theoretical chemists of the day, wrote to Berzelius in 1835: "Organic chemistry just now is enough to drive one mad. It gives me the impression of a primeval tropical forest, full of the most remarkable things, a monstrous and boundless thicket, with no way of escape, into which one may well dread to enter." Today, although a part of the forest has been mapped, no one feels that he has encompassed it. The most remarkable things are yet unknown.

Soap

An approach to chemical work quite different in its basic nature is illustrated by the early utilization of soap. The practical chemistry of older civilizations included empirical knowledge of many useful chemical processes, such as dyeing, pottery making, obtaining metals from ores, and fermentation. Empirical knowledge, in this sense, is of the sort based on the experience that clay can be baked to make pottery, even though the reason that the process works is not understood. Materials behaving like soap were obtained from plants and used for centuries;—they are still used to some extent in China and South America.

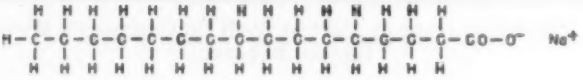


FIG. 5. Structural formula for a typical soap, sodium palmitate.

The water in which "pot ashes" had been soaked was also a cleaning agent of sorts. The accidental discovery that animal fat, when warmed with such water, gave a still better cleaner is not clearly described. The process was used by the Romans and described by Pliny. The cleaning agent formed by the process was a detergent, a true soap, used for centuries before anyone knew what it contained, much less what its structure was. As a matter of fact, the process that Pliny described for making soap was used until 1825 with little change, and in the eighteenth century it provided, by way of the soap tax, a major source of income for the English treasury. After that time the development of the LeBlanc process for making soda, and Chevreul's studies of the constitution of the natural oils and fats led to a knowledge of soap structure, and then to the manufacturing processes used today in the soap industry.

The experimental work on the problem of soap structure followed a pattern similar to that described for benzene, and without considering in detail the methods used to attack this problem of structure the end result is shown in Figure 5. The standard process for making soap from animal fat (or now from vegetable oils) is shown schematically in Figure 6. A typical soap molecule has the structure shown. Such a structure could not be seen—the illustration is best considered as a schematic diagram, a reasoned guess as to what the smallest particle of soap must consist of. At this stage, it was a hypothetical structure reasoned on the basis of its chemical reactions, and indirect evidence only supported it.

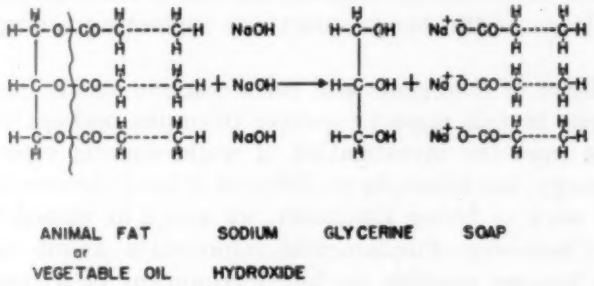


FIG. 6. Preparation of soap from fat or vegetable oil by saponification.

As such it implied that a molecule must have shape and dimensions. Some of the earliest measurements of molecular shapes and dimensions were made less than forty years ago. A description of that work invites a digression on the experimental techniques in chemical work.

Molecular Sizes and Shapes

Many problems in the natural sciences have to wait for the development and application of new instrumental methods before the full story can be disclosed. The development of the electron microscope, or of the cyclotron are obvious examples. That situation appears dramatic enough but not uncommon. Much less common and even more dramatic is the appearance of a painstaking investigator who, using nothing particularly new or expensive in the way of instruments, yet by superior experimental technique discovers things not known before. This situation is rare enough nowadays. The growth of wonderful new instrumentation makes many scientists fear that it is hardly worth while developing skillful and painstaking techniques today since tomorrow the advances in instrumentation may make them totally unnecessary. But every scientist knows that the real test, the shibboleth that distinguishes the mediocre or the merely competent scientist from the great natural scientific genius

is this very ability of the man to transcend the instrument. In the long run everything that can be exposed by the use of instruments will be exposed: it will not much matter who the investigator is; if it be not Jones of Great Britain it will be Smith of U.S.A. or Robinson of New South Wales.

The really triumphant kind of scientific contribution is the kind that in all the world only *one* man would do. Granted the original idea, probably many others could develop the technique. Yet the contribution lies not merely in the idea, but in the combination of thinking of it and being able to carry it out. But so closely allied are the functions that probably were the so-called mechanical skills lacking, the idea would never have come either. Head and hands work closely together, the knowledge of the hands sometimes suggesting concepts to the head.

The subject of detergents and surface-active agents has also had its triumphs in this respect—quieter triumphs perhaps than those that come from the investigation of world-shaking topics such as nuclear energy, but triumphs no different in kind. An excellent example is the work of Irving Langmuir, for which he gained the Nobel Prize in Chemistry. Fundamental information about the size of molecules became possible by his development of a really simple technique, using an apparatus that can be put together even at today's high prices for less than fifty dollars.

Detergents including soaps and the synthetic materials belong to a larger general class of compounds that combine two opposite properties, functions of their molecular structure. The non-mixing properties of oil and water are familiar, and are contrasted with the property of other compounds, such as common salt, or sugar, or vinegar of dissolving or mixing readily with water. Imagine a single molecule that combines in itself the non-mixing property of an oil with the ready-mixing property of salt or vinegar. What might be expected to be the behavior of such a singularly ill-assorted compound? The non-mixing or oily portion wants to separate from the water and the ready-mixing or polar portion wants to stay in the water. The result is an orientation at the surface of the water, with the polar end of the molecule sticking down into the water and the oily portion of the molecule jutting out away from the water surface. Even if the oily part of the molecule is made so large that the whole substance is completely insoluble in water, as for example stearic acid, yet if a small portion of it is placed on a clean water surface, the moleules will spread out over the surface, skating along with the polar portions submerged and waving the oily, non-mixing portion aloft above the water surface. Substances more soluble than this, to which class the soaps and synthetic detergents belong, also have an excess concen-

tration at the water surface, oriented in the same way as described above.

The presence of this monomolecular layer at a water surface can be demonstrated by a simple apparatus designed, at least in improved form, by Langmuir (Figure 7). The stearic acid film, spread in a layer one molecule thick on the surface, only partly covers the area between the barrier and the float. When the barrier is moved up towards the float, the surface area of water available for the monolayer is reduced, and the resulting increase of pressure, as the film itself is compressed so that it pushes on the float, can be detected by the recording arrangement. As this area is gradually reduced, the pressure begins to increase very markedly, until finally the whole film buckles up and its structure is destroyed.

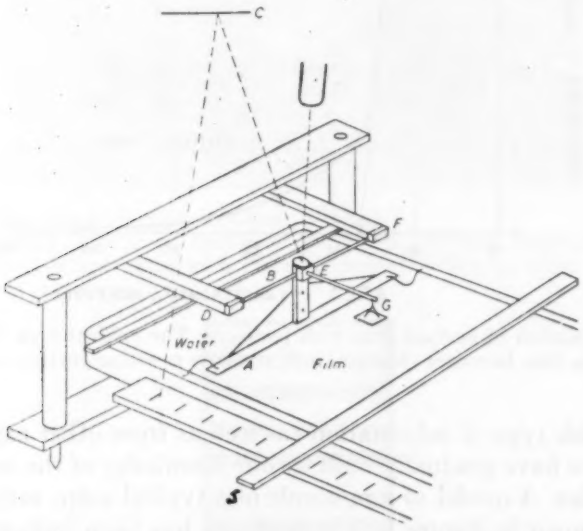


FIG. 7. Surface balance from designs by Langmuir and by Adam. The film is confined in an area which is made smaller by successive movements of the strip *S*. The resulting increased pressure tends to deflect the barrier *A*. The restoring force applied to the pan at *G* which is required to keep the barrier *A* at its rest point (as measured by the position on the scale of the spot of light reflected from mirrors at *E* and *C*) is recorded as a function of the area of the film.

Figure 8 illustrates the change of force with the area remaining between float and barrier, and the critical area marked is the actual area covered by a close-packed film under zero external pressure. This critical area can be compared directly to the area covered by a single molecule in the solid state, since the number of molecules is known. The cross-sectional area of a single molecule is thus calculated to be 20.5 Å^2 (100,000,000 Å equal 1 cm., or approximately 4/10 inch).

The volume of one molecule of stearic acid is known to be 556 Å^3, and the length of the molecule is therefore $556 \div 20.5$, or 27.1 Å. There are 18 carbon atoms in the molecule, and the distance between adjoining carbon atoms is 1.50 Å. Such distances are much too small to be measured by microscope; but they are confirmed by other, independent, methods developed more recently, such as X-ray diffraction.

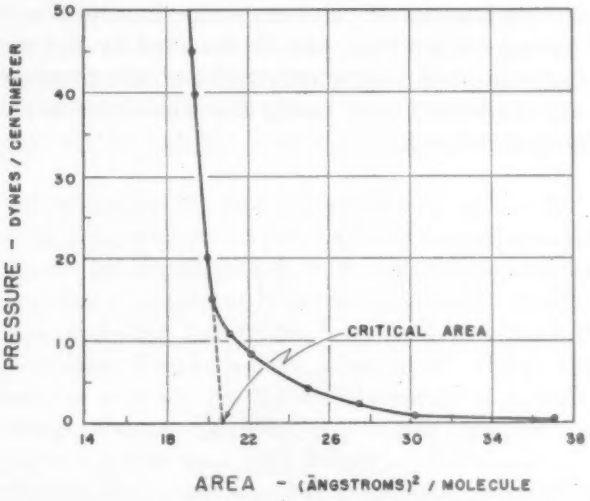


FIG. 8. Variation of surface area with pressure. The critical area is the point at which the film becomes close-packed, strongly resisting further compression.

From this type of information (as well as from other experimental sources) we have gradually built up our knowledge of the architecture of molecules. A model of a molecule of a typical soap, sodium palmitate, is shown in Figure 9. The scale, as has been indicated, is one hundred thousand to one. The long carbon chain is the oily, non-mixing part of the molecule, and the polar part is the small group at the end containing oxygen atoms. The general similarity in shape to the structural formula deduced earlier on the basis of chemical reactions is obvious. This is the sort of cross-checking which is a vital part of science, a vital point in forming a picture of the world that is consistent with behavior found in many fields of study.

The genius of this method of measurement lies in its simplicity and the ease with which molecular dimensions can be calculated. It has important applications in the study of complex organic compounds such as proteins and sterols, as well as in elucidating the mechanism of the biological reactions at cell membranes.

Mechanism of Detergent Action

A second example of valuable information obtained by simple means is in the use of photomicrographs to show the mechanism of detergent action. Photomicrographs have been in use for a hundred years and the action of soap on soiled clothes has been in use for very

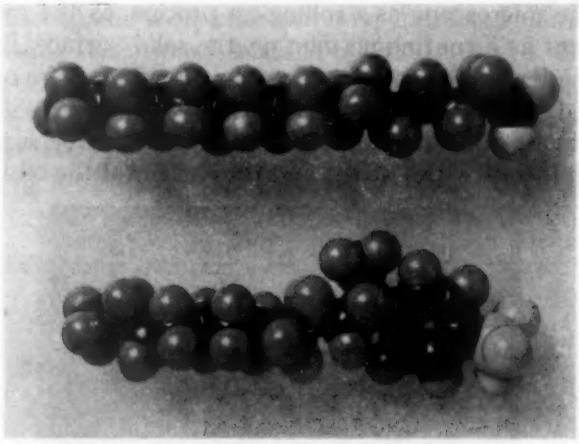


FIG. 9. *Top:* Model of soap (sodium palmitate).
Bottom: Model of synthetic detergent (sodium dodecylbenzenesulfonate). Models constructed with Fisher-Hirschfelder-Taylor atom models. The sodium ion is not shown.

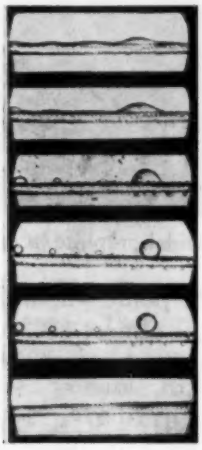


FIG. 10. Stages in rolling-up, in displacing grease from fiber.

many centuries. Yet only recently have really excellent and revealing photomicrographs, obtained by the combination of the highest technical skill, logical intelligence, and creative imagination produced

the results that these diagrams display. The photographs were taken by D. G. Stevenson and R. C. Palmer in the laboratories of the British Launderer's Research Association, and the work was sponsored by that organization. The action of a detergent is to displace the dirt, generally of an oily or greasy nature, from the solid surface and replace it with some of the detergent instead. This displacement is seen through the microscope as a rolling-up process, as the grease, originally present as a continuous film on the solid surface, is detached, collected and rolled up into droplets that finally adhere only loosely to the solid (Figure 10).

In Figure 10, there is an angle formed between the surface of the fiber which is wet by the water, and the surface of the oily particle in

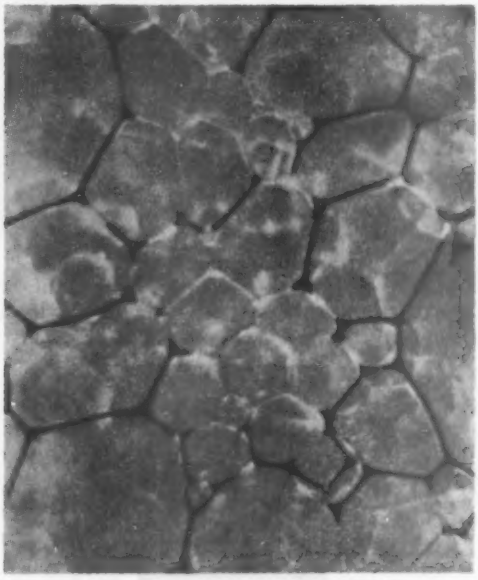


FIG. 11. Oildag (colloidal graphite in oil) dispersed, in foam.

contact with water, at the point where the oily particle, fiber, and water meet. This angle, θ, is almost 180° at first, and in the sequence diminishes to 0°. It diminishes because, in the relation

$$\cos\theta = \frac{\gamma so - \gamma sw}{\gamma wo}$$

where

γso is surface tension between solid and oil
γsw is surface tension between solid and water
γwo is surface tension between water and oil

the surface tensions are changed when a detergent is introduced. The

detergent is adsorbed as a monolayer, similar to those Langmuir studied, and this reduces γsw and γwo. The effect is to increase $\cos \theta$, or decrease θ and therefore to help roll up the grease. That is the mathematical way of looking at it. From the pictorial point of view, it is simply a pushing of the grease off the surface by the more surface-aggressive detergent. It has been compared to road-sweeping, where the dirt, at first spread more or less evenly, is collected into heaps for readier disposal. The disposal is aided by emulsification. Emulsification of grease or oil is further aided by the pressure of foam. The oil concentrates in the joints between the foam films (Figure 11). The dirt is thus broken up into fine lines which in turn break up into small droplets when the foam breaks. The droplets are then readily dis-

FIG. 12. Trace of colloidal graphite in oil, in coarse foam.

posed of again as an emulsion. The oil collects in these joints (sometimes called Gibbs' angles) because there the curvature of the film is greatest and the surface tension is effectively greatest (Figure 12).

By such means, it has been possible to learn how soap works to remove grease, and following this, to learn how the structure of soap, the polar–non-polar duality of function which we have discussed, is related to its ability to remove dirt, or its detergent action.

DEVELOPMENTAL RESEARCH

Synthetic Materials

The practical side of chemistry has always been in evidence. One aspect of this has been illustrated in investigations of the mechanisms

of detergent action. Another, and quite different illustration is the general success in making useful new materials by examining the molecular structure of a natural product, and then attempting to make, by chemical reactions, a structure which is similar. Sometimes it is difficult to determine what is the precise structure of the natural product. The structure of rubber, tremendously complex, is slowly being worked out by techniques, chiefly in the field of physical chemistry, which can hardly be discussed here. When a start had been made on that problem, in 1920–1930, it was possible to start research in the production of entirely new, synthetic materials which simulated its structure. The synthetic rubbers so prepared have improved as our knowledge of the relation of structure to properties has increased.

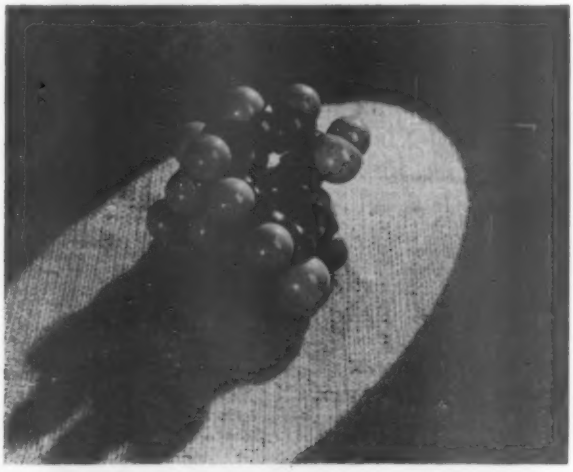


FIG. 13. Model of morphine molecule (Fisher-Hirschfelder-Taylor atom models).

The structure of morphine, early extracted from the Oriental poppy and still one of the best pain-alleviating drugs known, was suggested, after uncounted chemists had contributed pieces of information, in 1925 (Figure 13). A test of the correctness of a complicated structure is this: can the compound be synthesized from simpler substances, and is the synthetic material then identical with the natural? This is also a test of organic chemical theory, incidentally. The structure of morphine was thus proved by synthesis in 1952 by Marshall Gates and Gilg Tschudi (again it must be mentioned that these workers put together the last pieces of the puzzle that many others had worked on) at the University of Rochester. It is still easier by far to extract morphine from poppies than to manufacture it. Meanwhile, there had been synthesized a number of synthetic drugs simpler than morphine,

but containing some of the same structural features, once these were known. Some of these have been useful drugs; some are not as habit-forming as is morphine.

Synthesis of a Detergent

Research chemists at the I. G. Farbenindustrie, A. G. were the first to have the idea of making a synthetic compound which might have the same type of structure as soap. The physical chemist's picture of the mechanism of the action of soap as a detergent indicates that there are two essential features: a long chain of carbon (and hydrogen) atoms, and a terminal cluster of atoms which are water soluble, a polar group. In soap, the long carbon chain is the oil-soluble, water-

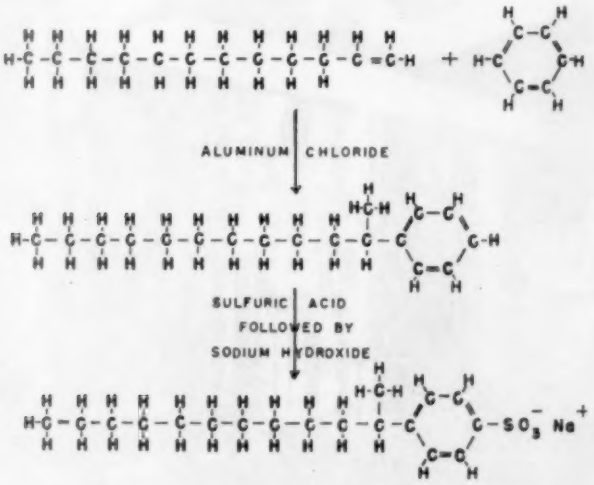


FIG. 14. Synthesis of an alkylarylsulfonate.

insoluble portion; the carbon-oxygen-sodium salt is the water-soluble, polar group. The dimensions, i.e. length of carbon chain, and many other factors are important. Several synthetic compounds (the Germans called them Igepons) were developed, which simulated the structure and dimensions of soap.

The compounds and reactions discussed earlier now fit into the picture. A hydrocarbon with a chain of, roughly, twelve carbon atoms is available in very large amounts as a by-product of petroleum processing. It has some uses, limited nowdays, as kerosene. The Friedel-Crafts reaction, which we have discussed, affords a way of coupling this to benzene (Figure 14). The reaction of this hydrocarbon with sulfuric acid is similar to the reaction of benzene with sulfuric acid to form benzenesulfonic acid, which has also been discussed. Finally,

this acid forms a sodium salt by reaction with sodium hydroxide. The resultant molecule is similar in dimensions to a soap molecule (Figure 11). This alkylarysulfonate is therefore similar in many properties to soap; it is an excellent detergent.

Applications

The practical side of chemistry predominates in the remainder of the discussion. The chemist looks for advantages for the synthetic material which may make it more useful than the natural product. The alkylarylsulfonate made as illustrated has greater detergent

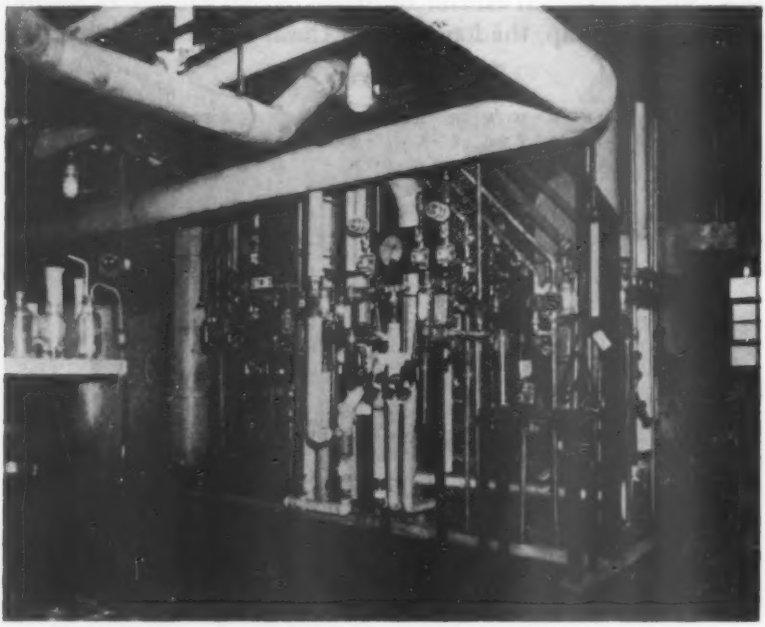


FIG. 15. Piping and continuous processing equipment for the production of Swerl (a domestic synthetic detergent) and Nacconols (industrial synthetic detergents) at the Buffalo Plant of the National Aniline Division, Allied Chemical & Dye Corporation.

action than soap—so much that it must be diluted with inert material or the lady of the house will waste it (or will think that she is getting too little material for the price). It works well in hard waters, where soap forms a curdy mess that is harder to remove than the original dirt. It does some things that soap can not do—some detergents of a slightly different type are excellent agents for destroying bacteria. The practical chemist then assays the economics of the problem—can the material be made on a large scale? Can it be produced cheaply enough to compete in the market with a material of established use? Here the laboratory reactions must be reinvestigated on a small

scale, to see if there can be improvement on the amount of the finished product made per unit amount of starting materials. The scale of operations is increased to the pilot plant stage—many laboratory reactions, because they require precise time and temperature control, are difficult to control when batches are processed which are a hundred or a thousand times larger than those used in the laboratory.

And somewhere in this stage of development, the problems become engineering ones, also. The equipment to conduct large-scale reactions most efficiently represents a major effort of design, construction and operation (Figures 15 and 16). These sound, in scope, like the earlier

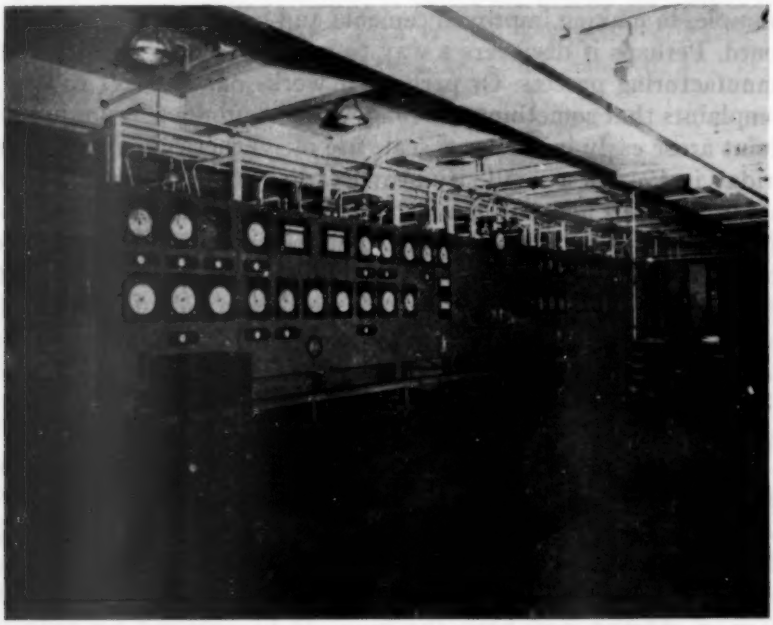


FIG. 16. Instrument control panel used in the production of Swerl (a domestic synthetic detergent) and Nacconols (industrial synthetic detergents) at the Buffalo Plant of the National Aniline Division, Allied Chemical & Dye Corporation.

problems of the discussion. But here, for commercial production, the multitude of problems and the physical scale of the work requires that many more individuals contribute than have previously been involved in all stages of the earlier problems. That is one reason why chemical engineers outnumber chemists. An extensive discussion of this work is not appropriate here. It must be mentioned, however, that a great variety of types of work is involved; a factory producing a synthetic detergent requires close analysis of the starting materials and of the product, and requires continuing physical tests of the prod-

uct to maintain its standards. The color, appearance, and odor must please the purchaser. The last factor, at least, may be left to the operations of a perfume chemist, who blends in a small amount of a pleasant-smelling compound (again synthetic) to mask slight odors which may be present in the detergent.

A modification of the structure of the detergent may improve it; the company maintains a research laboratory investigating these possibilities in laboratory bench work. Perhaps this research work leads to the discovery of a new chemical reaction, quite unrelated to the interest of the company. Perhaps it develops a use previously undreamed of for the product, as these materials are now used, for example, in making improved cements and better fiber board or wall board. Perhaps it discovers a way to reduce costs by modifying the manufacturing process. Or perhaps it works out answers to factory complaints that something is wrong with the product. A unique complaint arose early in the large scale use of synthetic detergents. On a Friday in 1947 in a small city near Reading, Pennsylvania, a manufacturer made a house-to-house canvass, distributing one-ounce samples of a new synthetic detergent. The following morning, operators at the city waste treatment plant noted large volumes of suds in the separating tanks. The suds increased steadily in volume during all of that day and the next. By Monday morning the foam, five feet deep, had practically submerged the plant. It lasted, in severe form, for two weeks. This is an embarrassing way of demonstrating that the research people had done a good job.

Then there are activities less related to the chemistry of the product or process, but still requiring chemical knowledge—transportation of raw materials, packaging, sales. Most chemists like to think of these activities, particularly some of the more extravagant sales techniques, as only very distantly related to their field of work. And, often, a chemist may have the requisite background for executive work.

Production of synthetic detergents is a large business. Bar soap is still soap, but synthetic products of this type are appearing. More than half of the household packaged "soaps" are now synthetic, and some twenty-five pounds per person per year are used. And the special uses in textile processing, dyeing, emulsion polishes, industrial cleaning and innumerable other applications are on almost as large a scale. But the scale of the work, or the nature of the materials prepared are not essential points in the discussion. Any one of a very large number of materials, some more important and some more glamorous, might have served as well as a starting point for the discussion.

ACKNOWLEDGMENT

The biographical article by Oesper[2] has been helpful in discussing the work of Friedel and Crafts; it contains interesting reproductions of their original laboratory notes. The photographs illustrating the mechanism of detergent action[3] are included by courtesy of Professor Adam, *Endeavour*, and the British Launderers' Research Institute. The photograph of the morphine molecule was supplied by the Fisher Scientific Company, and those of the equipment for the manufacture of detergents by the National Aniline Division of the Allied Chemical and Dye Corporation.

Several of the author's colleagues have contributed portions of this description, or have assisted with critical suggestions. Particular acknowledgment is due to Sydney Ross, Chris Sanford, and H. S. van Klooster.

[2] Oesper, R. E., *J. Chem. Ed.*, 26, 3 (1949).

[3] These are from the work of Adam, N. K., and Stevenson, D. G., *Endeavour*, 12, 45 (1953).

NEW OPTICAL DEVICE, AXICON, ELIMINATES NEED OF FOCUSING

A new kind of optics, which makes possible an unusual sort of lens without definite focal length, makes its bow in a communication to the Optical Society of America. Dr. John H. McLeod of Eastman Kodak Co. is the physicist who made this development.

Axicon is the term applied to the new class of optical elements. Axicon means axis image. Axicons form a continuous straight line of images from small sources.

The most important axicon is a glass cone. This can be used in a telescope. The usual spherical objective is replaced by the cone. This axicon telescope is in focus for targets from a foot or so to infinity without the necessity of moving any parts. It can be used to view simultaneously two or more small sources placed along the line of sight.

Add a source of light and this kind of telescope becomes an autocollimator, which can be used to determine whether a mirror is perpendicular.

A search for a universal-focus lens led to this new class of optical elements.

APPEAL GETS 35 PAIRS OF TWINS FOR MS STUDY; MORE NEEDED

Thanks to cooperation of hundreds of newspaper editors, the National Multiple Sclerosis Society has now located some 35 pairs of identical twins in 19 states who are afflicted with MS, short for multiple sclerosis.

The twins will take part in a study designed to show whether or not there are hereditary or environmental causes of the disease. Ideal twins for the study would be those pairs of identical twins of which one has the disease and the other has not.

Since identical twins develop from the same egg cell, or ovum, the hereditary background would be identical. Differences in environmental factors would then be searched for possible causes of the disease in the one twin and not the other.

While the first 35 pairs of twins are being processed to make sure they are identical and that one or both has MS, the society is continuing its appeal for more MS twins.

A PROGRAM FOR INCREASING STUDENT INTEREST IN SCIENCE

J. STANLEY MARSHALL
State University Teachers College, Cortland, New York

The posters advertising the Science Show had been up for days. The plans were finally complete and the last minute details worked out. The student body filed into the auditorium and were seated. The curtains parted and on the stage could be seen a large and curious assortment of equipment and materials. Standing prominently in the foreground was what seemed to be a very large, crude picture frame, perhaps 3 feet by 6 feet. But where the picture should have been, there was only an expanse of gray paper. Nothing. The seconds passed. No performers appeared. The audience, sensing some failure or delay, began to titter, and still the seconds wore on. Then suddenly, as if by magic, the gray paper began to smoke, then to glow and within a moment burst into flame, spelling out the word WELCOME. While the audience applauded enthusiastically the President of the Science Club entered and officially welcomed the students, and the show was on!

But this was more than just another assembly program, more than just a means of providing entertainment for the student body. This was the climax of nearly a year of hard work and feverish activity by the members of the Science Club. This was the finished product that had resulted from the labors of the club members to establish a program of science activity that would bring new life to the club and meaningful science experiences to its members. To understand how this program developed and grew, we must go back almost nine months to the previous October when the Science Club's plans for the year were being prepared.

A few weeks after the opening of school in the fall, the Club's officers, who had been elected the previous spring, met with the faculty sponsor to discuss plans for the year. The officers vowed that this year the Science Club was to have the best year in its history and the spirit with which they set upon the task of planning the year's program gave notice of their sincerity. It was agreed that to achieve this goal, every member would have to participate actively in the regular club projects. Consequently, at this meeting the club membership was divided into several committees, each committee consisting of three or four members, the chairman being one of the older, more experienced science students. Then club-meeting dates were assigned to each committee until all of the dates had been allotted. Each

committee was charged with the responsibility of preparing and presenting a suitable program of science experiments, demonstrations or discussions for the club on their assigned dates. Most committees were asked to serve twice during the year with an interval of several months between appearances. In making up the overall program, the school calendar was examined carefully to ascertain exactly how many club meetings could be held. This program was presented to the club when it assembled for its first regular meeting, and received the enthusiastic approval of the membership. The president then announced the makeup of each committee and followed this with an explanation of their responsibilities. Special emphasis was placed on the job of the chairman in having his group select their projects, in arranging times when all members could meet for work and in calling on the club sponsor for help and guidance and for procuring whatever materials and equipment they would need.

At the following meeting the first committee presented their demonstration. It should be noted here that the first two or three programs were presented by the older, more experienced science students, with the neophytes being given the opportunity to learn from these programs, and also being allowed more time to prepare their own. This demonstration was in the field of chemistry—a display of "fire-writing," using a solution of white phosphorous in carbon disulfide painted on a sheet of asbestos paper which was fastened to a large wooden frame. This spectacular demonstration was a great hit, and it served to stimulate the rest of the members to improve the quality of their presentations. Of course considerable care had to be exercised due to the dangerous nature of the chemicals used. Following the display, a discussion period was held, led by members of the committee, touching on such matters of scientific importance as oxidation, kindling temperature, products of combustion and methods of handling dangerous materials.

In another early presentation, a solid mercury hammer was made by pouring the liquid into a mold placed in a beaker containing acetone to which pieces of solid carbon dioxide were added. The hammer was used to pound nails and do other similar jobs. The demonstrators carefully pointed out that when the mercury hammer struck a solid object, the mercury seemed to melt at the point of contact. The discussion following this demonstration included such points as the effect of pressure on melting solids, what molecules do when liquids freeze, and how the acetone and carbon dioxide could produce so low a temperature. Still another program presented early in the year consisted of the demonstration of a home-made atomizer. The rest of this club meeting was devoted to a discussion of sprays of various kinds, airplane wings, curving baseballs and the like.

As the school year progressed, the success of the program led some of the club members to think about putting on a science show for people outside the club membership. The sponsor had tentatively accepted a date later in the year for a science assembly program and this seemed to be the answer. The project was turned over to the club and from this point on, the same kinds of presentations continued to be used for regular club meetings with the thought that these, as well as the preceding ones, would be rounded into shape to be used for the assembly program. In planning such a show as this, the club members knew they had a number of important factors to consider. The audience would be made up of the entire student body of about 600 students, from grades seven through twelve. The program would have to be sufficiently mature to interest the seniors and yet be simple enough to appeal to the seventh graders. Demonstrations would have to be such that they could easily be seen and heard by a large audience. Entertainment was not to be the only goal of the program; it was to be designed to teach as well. The off-stage space in the auditorium was limited, thus prohibiting the use of large equipment or the shuttling on and off stage of any sizeable quantity of material. Of course the usual provisions for special lighting and other effects had to be worked out. These and other factors had to be considered by the club in planning the program.

In the early stages of planning, the club decided to divide the demonstrations into three categories in line with the traditional divisions of high school science—chemistry, physics and biology. The president then appointed three committees, one to be in charge of the final preparations in each of these areas. Their first job was to select those presentations that they considered best suited for use in a science show. Next they would have to refine those selected—to make certain all the rough points were smoothed off and made suitable for presentation to an audience. Finally, the job of fitting various presentations into an organized program had to be worked out. And of course the usual "dress rehearsals" had to be held to make certain things would go off as they were supposed to.

The program itself is presented here in its entirety and in some detail for possible use by science teachers who desire concrete information on how to put on a science show.

The show's opening was meant to be spectacular. The fire-writing previously described was well received and served to get the program off to a good start. Of course this trick of making up a solution of phosphorus in carbon disulfide of just the right concentration, then using it to paint the letters on the asbestos paper the required number of seconds before opening the curtain, was achieved only after several trials.

After the president's welcome, he introduced another club member who was to act as narrator for the first part of the show. The demonstrations in the field of chemistry came first.

The ammonia fountain. This was achieved by using a large television picture tube that had not been coated inside. This tube had previously been filled with ammonia gas in the school laboratory and was suspended from above by wires. The glass tubing extended from the tube to a large jar of water on the table below. Phenolphthalein had been added to the water so that the fountain appeared red. This added to its showiness" and also brought indicators into the demonstration. There followed a short explanation of this presentation by the members of the committee who were responsible for it. They talked about solutions and indicators and casually performed the "water into wine" trick to aid in the explanation.

Using chlorine to bleach cloth. A club member who was seated in the audience "volunteered" to go on the stage to help with the demonstration. Under feigned protests, his necktie was removed and placed in the bottle of gas and bleached white. Of course a sample of this cotton cloth was found earlier to be suitable for use here. This precaution should always be observed.

Fun with carbon dioxide. Several small pieces of solid CO_2 were placed in a beaker containing a little acetone, and the mercury hammer discussed previously was made by pouring the liquid into a small match box and submerging it in the freezing mixture. A handle in the form of a pencil was inserted before the mercury hardened. After a minute or so the hammer was withdrawn and the box removed. Then a number of objects including a rose, some grapes, and a wiener were dropped into the mixture for a moment. The mercury hammer was used to pound these frozen objects on the table and the shattering of rose, grapes and wiener was very effective. At this point as well as several others, a bit of sparkle was added to the program by the demonstrators tossing fragments of these materials out into the audience.

During the preceding demonstration, a piece of solid CO_2 was left in a large beaker so that a sizeable portion of CO_2 gas would be collected. The next demonstrators lit a candle, placed it in a small beaker, and by means of a long, paper chute, poured the CO_2 gas from the large beaker and extinguished the candle. In this case, as in some others, the program was kept from dragging by having one club member perform the demonstrations while another explained the science involved. His brief explanation here centered on the chemical and physical properties of CO_2. He also explained that this gas was formed in a number of ways and as he spoke, still another demonstrator touched a match to a wad of paper in large bucket on

the other side of the stage. This was a signal for two other demonstrators to rush from backstage, quickly drop some sodium bicarbonate into a large bottle of dilute sulfuric acid, place in the mouth a stopper fitted with a short nozzle of glass tubing and proceed to extinguish the fire. In this demonstration it was important to employ a husky boy to hold the stopper securely in the bottle as the gas evolved and collected under pressure. Of course the quantities of reagents had been carefully measured out and placed on the table in advance. The explanation that followed dealt with the familiar fire extinguishers found in the school and home.

The biology committee had decided that the most fascinating and enlightening demonstration possible to present to this large audience would be to show microscopic views of several objects studied in biology. The Bioscope, with condenser tube attached, was to be used to project images onto the screen. Previous trials had shown that in order for these images to be clearly visible to those seated in the back, the room had to be almost totally dark. So at this point, several pairs of boys equipped with large blankets went to the large double doors (where light came in the openings between doors) and held up blankets, thus effectively reducing the light. The following specimens were shown: a small spider, a cross-section of a dicot stem, a longitudinal view of a similar, woody stem, a living hydra, conjugating spirogyra, some bread mold freshly grown for the purpose, a cross-section of small intestine (mouse) showing villi, some living paramecia and the wings and legs of a housefly. While these were being shown, another member of the club acted as narrator, touching on such things as the eight legs of a spider and the fact that it is not an insect, the role of xylem and phloem in carrying materials inside the tree, how hydra feed and where they can be found, reproduction in lower plants and animals, the role of villi in digestion of food and the housefly's excellent equipment for carrying dirt wherever he goes. Perhaps the single factor most important in making for a successful presentation here was the running comment carried on by the student at the microphone. The commentary had to be timed to go along with the object being shown on the screen and had to be flexible in view of the fact that the movements of the hydra's tentacles, for example, could not be anticipated. And of course there is some challenge in holding the attention of six hundred students in a darkened auditorium.

Physics came in with the whirring of an electric motor and the hissing of air. Showmanship demanded that an active, moving demonstration following the preceding twenty minutes of intense concentration on the objects from the world of biology.

The first demonstrator in physics suspended a ping pong ball, then an inflated balloon, in the air stream from motor-driven pump. He

moved around the stage, "leading" the ball with him and pointing out its direction of spin and the narrator talked about airplane wings and curving baseballs. Next an atomizer was made, using the same air stream and with it some red ink was sprayed on a white card. Appropriate comments about perfume, chimney drafts, and paint sprayers followed.

Sound came in for some discussion as the air stream was directed into the holes in a revolving metal disc producing the siren effect.

The mercury hammer which had been laid aside after its brief use previously, was now shown to be quite solid even after lying on the table, at room temperature, for considerable time. At this point the demonstrator struck the table several solid blows with the hammer after which it was very much reduced in size. The liquid mercury could be seen on the table top. After several more blows the hammer ceased to exist, leaving nothing but a quantity of liquid, some of which was collected and poured into a bottle to add to the effect. This led the commentator into an explanation of the freezing of snow into ice on the highways by passing cars, and of course, into some further comments on how molecules behave under various conditions as well as a few, brief remarks about energy.

The next demonstration in physics was a simple one related to light and the spectrum. As the narrator explained that we see things due to reflected light and that colors are due to reflected light of different wave lengths, the demonstrator produced a large picture with a variety of bright colors. The audience was asked to observe it carefully under the normal incandescent light. The lights were then turned out and a quantity of borax (over which a little alcohol had been poured) was ignited. The predominant yellow color which resulted from the sodium in the borax intensified the yellow in the picture and "washed out" the other colors effectively, giving the picture an entirely different appearance.

The final presentation was a demonstration in electronics. Most of the audience had seen doors being opened by control of "electric eyes" and many were familiar with the role of the photoelectric cell in the school film projectors. The narrator took advantage of this acquaintance to present a short talk on moving electrons and the effect of heat, light and other energy on their emission. Following this, two of the club members quickly hooked up a circuit containing a lamp and a photocell and showed how the lamp could be controlled by the presence or absence of light of sufficient intensity falling on the sensitive metal in the photocell.

On the same general topic, a cathode ray oscilloscope was demonstrated. It must be stated that no attempt was made to explain to this audience the principles of its operation. The main purpose was

to show, by means of a carbon microphone attached to the oscilloscope, that energy can be converted from one kind to another, and secondarily to end the program on a lively note. Both of these objectives were accomplished by asking the school's outstanding soprano to sing softly into the microphone (sine wave changed to a series of smooth, frequent pulsations), then having the boy with the big bass voice sing loudly (now waves of great magnitude, will spread out) and finally, after the comment by the narrator that "we all know how the principal's voice *sounds* when we're called to the office —now see how it *looks*," having a gruff voice shout into the microphone, "John Jones will come to the office immediately!" With this, the show was ended.

As a means of determining the value of this type of activity for a science club, the sponsor attempted to analyze and evaluate the program for the whole year as well as the science show itself. Some of the benefits are as follows: (1) the committee work provided meaningful activity for every member of the club, making each feel that his contribution was important and, in fact, necessary for the meetings' success; (2) the committee work provided valuable training and experience in science and particularly in handling equipment and materials for each member; (3) the necessity for performing before and talking to a group provided an opportunity for the members to acquire poise and confidence; (4) such a program is easily carried out since the plans for the entire school year are made early in the fall and each club member knows well in advance what is expected of him. Most significantly, it can be safely stated that the program seemed to be almost wholly responsible for new life and activity in the science club.

In addition to the benefits to the club members, there were also certain desirable outcomes affecting the students generally. Some of these were: (1) a greatly increased interest in science as a school subject; (2) an apparent increase, at least in some cases, in science in everyday life (although this latter is difficult to measure objectively); (3) an entirely new attitude toward the science club as reflected by the number of applications for admission, (4) the knowledge that within the school can be found the resources—both in personnel and materials—for good assembly programs.

What greater or better gift can we offer the republic than to teach and instruct our youth?—Cicero.

Every individual has a place to fill in the world, and is important in some respect, whether he chooses to be so or not.—Hawthorne.

FOURTH YEAR MATHEMATICS AS THE KEY TO OUR SUPPLY OF SCIENTISTS

WILLARD GEER
University of Southern California, Los Angeles 7, Calif.

The critical need of this country for 50,000 scientists and engineers calls for strong steps to unlock the present bottleneck in our supply. With only 20,000 scientists and engineers available and with the need so critical that even the graduating engineer with the lowest grades last year, at Southern California was offered, five positions, something drastic needs to be done. Science Fairs, Science Clubs and Talent Searches all do a part to help, but the few per cent which each of these projects adds can never be enough to supply the two- to three-fold increase needed.

To better understand the problem, let us look at the enrollment in high school mathematics. In the ninth grade almost all freshmen take algebra or general mathematics (1.7 million) and half a million take geometry in the tenth grade. This falls to a quarter of a million, in the eleventh year, continuing in mathematics, as perhaps it should, considering the higher intelligence required. But even here 23 per cent are still taking mathematics. However, during the fourth year only ten per cent (100,000) of those going on, take fourth year mathematics. Out of these 100,000 who have had four years of mathematics comes our supply of 20,000 scientists and engineers. The ratio of one out of five going into science is not itself wrong. Not all who graduate with an adequate mathematics preparation can go on to college, and surely other fields than science and engineering have a right to draw from this pool. Rather than to attempt to secure our 50,000 needed scientists from these 100,000 and thus seriously curtail the supply of beginners in other professions, is not the answer to our problem one of increasing the size of this pool? This increase should be of the ratio of 50,000 to 20,000. If this pool could be increased by the 5 to 2 ratio it would mean, in terms of mathematics enrollment, that the 250,000 now taking intermediate algebra would continue on and take some fourth year mathematics. Most mathematics teachers agree that students finishing intermediate algebra have the ability to take trigonometry and solid geometry.

We naturally wonder if there are alternates to raising this pool of students to 250,000 or if we can even raise it at all. We also wonder just what we as science and mathematics teachers can do from where we are.

First: How can we help to meet this need? The easiest way is to divert students to science from other fields. Here, when we try to get

engineers or scientists, we run into the mathematics bottleneck again. These students have not had enough mathematics, and a year or two more in college would be required to clear up mathematics deficiencies in order to allow the student even to start. Often, just because of their inadequate mathematics background we lose students to other fields. Indeed the diversion too often goes the wrong way. An almost tragic loss is reported by Fletcher Watson who estimates 41% of starting science teachers are diverted to industry in their first year after graduation. No policy of "robbing Peter to pay Paul" can be a workable answer.

Another measure—adult education—(wherein the man, ill-advised as a boy in high school returns at night, after work, to correct his advisor's mistakes) can help to some extent. But why not give the right advice at the right time?

Colleges can and do offer high school mathematics to those who did not take it at the secondary school level, but the sequential nature of college science and engineering courses seems not to be understood by advisors in secondary schools. Because of this ordered sequence, trigonometry postponed to college means postponement of *all* science and engineering. The four years planned for college becomes then a five- or six-year schedule. Too often this extra expense can be afforded neither by the student nor his parents and he switches his major away from science into some field not requiring the mathematics he missed in high school. Taking high school mathematics in college is not the right answer to the problem.

Then we come to the real problem: How can we get started on having 250,000 instead of 100,000 take 4th year mathematics? Education of school principals and advisors is the answer. Parents of potential scientists, too, need to know that four years of mathematics is the most important sequence such students can take in high school, regardless of what average college entrance requirements say. They must plan courses by giving first place to mathematics. If conflicts develop between mathematics and physics; students should drop physics; if between chemistry and mathematics, students should drop chemistry. Taking it further, one would recommend that students drop foreign language,—drop everything except what is required by state law,—but keep mathematics throughout the four years. Let all students who take intermediate algebra, all 250,000 of them, go on through the next year and then we shall have our pool of scientists from which to draw our needed 50,000 scientists and engineers.

We teachers of physics, chemistry, engineering and mathematics must work together to fuse in the minds of all advisors, principals and parents, the advice: "Taking science?—Take mathematics."

To put this idea to all who need to have it implanted in their minds is not easy. All societies should unite and press it. Could we not have one top man bring together all the efforts of all organizations and publications to a focus upon this key problem?

SIMPLE APPARATUS FOR DEMONSTRATING PRESSURE IN WATER PIPES

MENNOW W. GUNKLE
Thornton Township High School and Junior College, Harvey, Ill.

At some time during the High School course in a physical science, either chemistry or physics, the gas laws are encountered. Generally, students know that a gas can be compressed but their visual experience with such a phenomenon is usually limited. It is possible to stimulate interest in one instance by showing how the pressure in the water pipes running through the laboratory can be calculated. The apparatus is simple and demonstrates Boyle's law of increased pressure. This may be used in connection with the apparatus for showing decreased pressure.[1]

MATERIALS NEEDED FOR DEMONSTRATION

Eudiometer tube, 50 ml.
Heavy pressure rubber hose, 2 feet long
Copper wire to clamp hose to E-tube and water outlet

PROCEDURE

Attach one end of the heavy hose to the open end of the eudiometer tube and draw the copper wire around tightly and twist. The lip of the eudiometer tube also helps hold the rubber hose in place. Water should be admitted to the hose and above the level of the mark on the eudiometer tube. The water is admitted to try to equalize the pressure inside the eudiometer tube with the atmospheric pressure. Then the other end of the hose should be fastened to the water outlet with wire. An approximate adjustment is made so the water level inside the eudiometer tube is nearly at the same level as the end of the outlet on the water faucet.

CALCULATION

Take a reading of the air volume in the eudiometer tube and record the data as the initial volume. The initial pressure can be obtained from the barometer. Changing to the English equivalent is approxi-

[1] Gunkle, Mennow M., "Simple Apparatus for Demonstrating the Gas Laws," SCHOOL SCIENCE AND MATHEMATICS, LII (November, 1952), pp. 614–616.

mated by allowing 0.2 pound per square inch for each 10 millimeters of mercury pressure, as follows:

760 mm. Hg approximates 14.7 lbs. pressure per sq. in.
750 mm. Hg approximates 14.5 lbs. pressure per sq. in.
740 mm. Hg approximates 14.3 lbs. pressure per sq. in.

Turn the faucet ON and allow the water to climb in the eudiometer tube until it comes to rest. The compressing of the original volume of air can be observed. The increased pressure, from the water pipe, has now decreased the volume of air inside the eudiometer tube. (Disregard solubility due to increased pressure.) Again take the volume of air in the eudiometer tube under the changed pressure. The pressure which caused the change of the original volume of air to the smaller volume can be calculated from Boyle's law, Temperature constant, and is equivalent to the pressure in the water pipe.

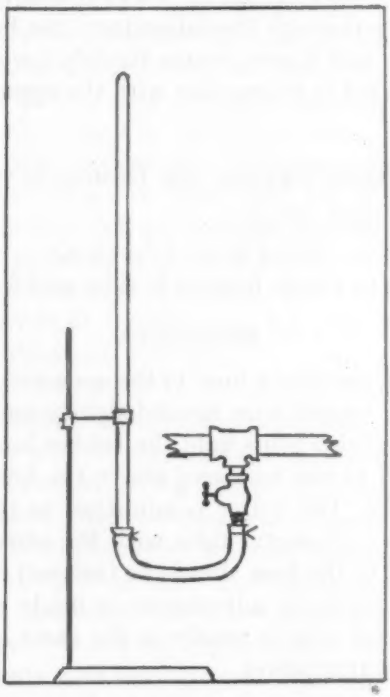


Diagram of apparatus for showing pressure in water pipes.

The crowning fortune of a man is to be born to some pursuit which finds him employment and happiness, whether it be to make baskets or broadswords, or canals, or statues, or songs.—Emerson.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
Harris Teachers College, St. Louis, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, Harris Teachers College, St. Louis, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

2407. *Proposed by Leon Bankhead, Los Angeles.*

Show that for all positive values of p, q, r, and s

$$\frac{(p^2+p+1)(q^2+q+1)(r^2+r+1)(s^2+s+1)}{pqrs}$$

cannot be less than 81.

Solution by R. L. Moenter, Midland College, Fremont, Nebraska

The given

$$\text{fraction}=\left(p+1+\frac{1}{p}\right)\left(q+1+\frac{1}{q}\right)\left(r+1+\frac{1}{r}\right)\left(s+1+\frac{1}{s}\right).$$

Now the sum of a positive number and its reciprocal is $\geqq 2$.

Hence each factor above is $\geqq 3$ and the product is then $\geqq 81$.

Solutions were also offered by: Aaron Buckman, Buffalo, N. Y.; James F. Gray, San Antonio, Tex.; V. C. Bailey, Evansville, Ind.; C. W. Trigg, Los Angeles, Calif.; Felix John, Philadelphia, Pa.; William Dannacher, Wayne, Pa.; David Rappaport, Chicago, Ill.; Clinton E. Jones, Nashville, Tenn.; Norman Anning, Alhambra, Calif., and the proposer.

2408. *Proposed by V. S. Narayanan, Pudukkottai, India.*

If P be any point in base AB of triangle ABC, with AP equal to M, PB equal to N, and if angle C is divided by CP into angles ACP equal to α, PCB equal to β, and if angle CPB equals θ, then

(1) $$(M+N)\cot\theta=M\cot\alpha-N\cot\beta.$$

(2) $$(M+N)\cot\theta=N\cot\alpha-M\cot\beta.$$

Solution of Part I by Bro. Felix John, Philadelphia, Pa.

$$\sin A/a=\sin B/b;\ \sin(\theta-\alpha)/a=\sin(\theta+\beta)/b.$$

$$b(\sin\theta\cos\alpha-\cos\theta\sin\alpha)=a(\sin\theta\cos\beta+\cos\theta\sin\beta)$$

$$\cos\theta(a\sin\beta+b\sin\alpha)=\sin\theta(b\cos\alpha-a\cos\beta)$$

$$\cos\theta/\sin\theta=(b\cos\alpha-a\cos\beta)/(b\sin\alpha+a\sin\beta)$$

$$\cot\theta=\frac{b\cos\alpha/ab\sin\alpha\sin\beta-a\cos\beta/ab\sin\alpha\sin\beta}{b\sin\alpha/ab\sin\alpha\sin\beta+a\sin\beta/ab\sin\alpha\sin\beta}$$

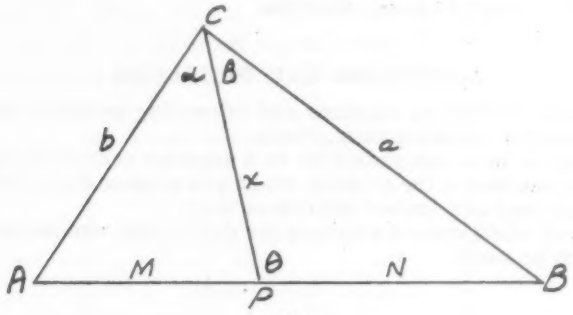
$$=(\cot\alpha/a\sin\beta-\cot\beta/b\sin\alpha)/(1/a\sin\beta+1/b\sin\alpha)$$

$$=(\cot\alpha/N\sin\theta-\cot\beta/M\sin\theta)/(1/N\sin\theta+1/M\sin\theta)$$

$$=(\cot\alpha/N-\cot\beta/M)/(1/N+1/M)=(M\cot\alpha-N\cot\beta)/(M+N).$$

Therefore, $(M+N)\cot\theta=M\cot\alpha-N\cot\beta$.

Solution of Part II by A. R. Haynes, Tacoma, Wash.



(2)

To prove $(M+N)\cot\theta=N\cot A-M\cot\beta$.

$$\frac{CP}{\sin A}=\frac{M}{\sin(\alpha=\theta-A)}\quad\therefore\quad CP=\frac{M\sin A}{\sin\theta\cos B+\cos\theta\sin B}\qquad(1)$$

$$\frac{CP}{\sin B}=\frac{N}{\sin(\beta=180-(\theta+B))}\quad\therefore\quad CP=\frac{N\sin B}{\sin\theta\cos B+\cos\theta\sin B}.\qquad(2)$$

Equating (1) & (2),

$$\frac{M}{\sin\theta\cot A-\cos\theta}=\frac{N}{\sin\theta\cot B+\cos\theta}.$$

Dividing denominators of both sides by $\sin\theta$.

$$\frac{M}{\cot A-\cot\theta}=\frac{N}{\cot B+\cot\theta}.$$

Whence $(M+N)\cot\theta=N\cot A-M\cot\beta$. Q.E.D.

(1)

To prove $(M+N)\cot\theta=M\cot\alpha-N\cot\beta$.

$$\frac{CP}{\sin(A=\theta-\alpha)}=\frac{M}{\sin\alpha}\quad CP=\frac{M(\sin\theta\cos\alpha-\cos\theta\sin\alpha)}{\sin\alpha}\qquad(1)$$

$$\frac{CP}{\sin(B=180-(\theta+\beta))}=\frac{N}{\sin\beta}\quad CP=\frac{N(\sin\theta\cos\beta+\cos\theta\sin\beta)}{\sin\beta}.\qquad(2)$$

Equating, $M(\sin\theta\cot\alpha-\cos\theta)=N(\sin\theta\cot\beta+\cos\theta)$

Dividing both sides by $\sin\theta$ and re-arranging,

$$(M+N)\cos\theta = M\cot\alpha - N\cot\beta.$$

A. R. Haynes notes that Problem 2408, Part I is given on page 113, 172, of *Trigonometry for Beginners* by Rev. J. B. Lock, The Macmillan Co., 1900, with a note referring to "Minchin's Statics, 36," and Part II is offered as an Exercise

2409. *Proposed by Bro. Felix John, Philadelphia.*

Show that $10^n+3\cdot 4^{n+2}+5$ is divisible by 9.

Solution by J. H. Means, Huston-Tillotson College

Let

$$f(n) = 10^n+3\cdot 4^{n+2}+5$$
$$f(n+1) = 10^{n+1}+3\cdot 4^{n+3}+5 = 10\cdot 10^n+3\cdot 4^3\cdot 4^n+5.$$
$$f(n+1)-f(n) = 10^n(10-1)+4^n(3\cdot 4^3-3\cdot 4^2).$$
$$= 9.10^n+9.16.4^n$$

This is divisible by 9. Hence if $f(n)$ is divisible by 9 so is $f(n+1)$. Taking the special case where $n=1$ we find $f(1)=207$, which is divisible by 9. Since $f(1)$ is divisible by 9, so is $f(2)$. Since $f(2)$ is divisible by 9, so is $f(3)$ and so on. This shows that

$$f(n) = 10^n+3\cdot 4^{n+2}+5$$

is divisible by 9 for all positive integral values of n.

This problem appears in Wright's Theory of Numbers, page 14.

Solutions were also offered by Edward J. Zoll, Levittown, N. Y.; C. W. Trigg, Los Angeles, Calif.; R. L. Moenter, Midland College, Fremont, Nebraska; Aaron Buchman, Buffalo, N. Y.; Charles H. Butler, Kalamazoo, Michigan; William H. Dannacher, Wayne, Pa.; Clinton E. Jones, Nashville, Tenn.; James F. Gray, San Antonio, Texas; D. McLeod, Winnipeg, Canada; Willis B. Porter, New Iberia, La.; Richard Bates, Milford, N. Y.; and the proposer

2410. *Proposed by Hugo Brandt, Chicago.*

Under what conditions is the following equation true for integers a, b, c:

$$a(a-c)-b(b-c) = (a-b)(a-c)(b-c).$$

Solution by C. H. Butler, C. S. Sams, and P. H. Doyle, Kalamazoo, Mich.

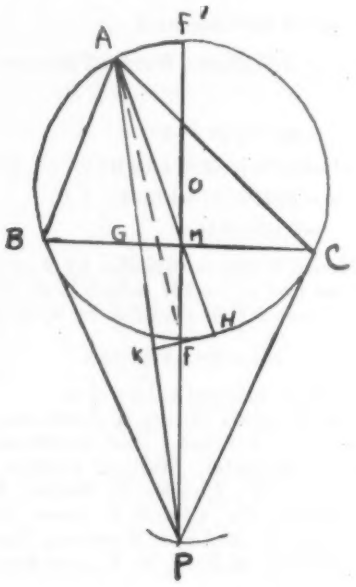
There are several cases to consider.

1. A trivial condition is that $a=b=c=0$.
2. If $a=b$ the equation is satisfied regardless of the value of c.
3. If $a=c$, $b\neq c$ then $b(b-c)=0$, whence $b=0$.
4. If $b=c$, $a\neq c$ then $a(a-c)=0$, whence $a=0$.
5. If a, b, c are all different non-zero integers, then by appropriate grouping and factoring the original equation can be put in the form $a+b-c=ab/(1+c)$. Since the left member of this equation must be an integer, it follows that the right member must also be an integer, or $(1+c)$ must be a divisor of ab. This, however, is not sufficient. Not only must this quotient $ab/1+c$ be an integer, but it must equal $(a+b-c)$. If three different non-zero integers can be found that satisfy these two conditions, they will satisfy the original equation. There remains, then, the final question of how to find such sets of integers. This can be done as follows. Taking $a\neq b$ and c any integer, set $c=d_1d_2-1$ where d_1 and d_2 are integers. This can be done since any integer y can be expressed in the form $y=px+q$ where p, x, and q are integers. Then let $a=d_1d_2+d_1$ and $b=d_1d_2+d_2$. With these substitutions the equation $a+b-c=ab/(1+c)$ becomes an identity. Hence d_1 and d_2 can be selected arbitrarily (or what is the same thing, c can be selected arbitrarily) and the resulting values of a, b, and c will satisfy the original

equation. This can easily be illustrated by taking any pair of integers to represent d_1 and d_2, or by selecting c at random and then using for d_1 and d_2 any pair of integral factors of $(1+c)$.

Solutions were also offered by R. L. Moenter, Fremont, Texas, and the proposer.

2411. *Proposed by A. R. Haynes, Tacoma, Wash.*



Point O is the center of the circum $\odot$ of $\triangle ABC$ and P is the pole of BC. PO bisects BC in M, and cuts the circum $\odot$ in F&F'. PA cuts BC in G.

(a) Prove that segment PM is harmonically divided by F&F'.

(b) Prove AG is the (A) symmedian of $\triangle ABC$.

Solution by A. R. Haynes, Tacoma, Wash.

(a) To prove

$$\frac{PF}{MF}=\frac{PF'}{MF'}.$$

1. $2R=PF'-PF$ or $R=\dfrac{PF'-PF}{2}$

$OP=R+PF$

$\therefore\ OP=\dfrac{PF'+PF}{2}$

2. $2R=MF+MF'$ or $R=\dfrac{MF+MF'}{2}$

$OM=R-MF$

$\therefore\ OM=\dfrac{MF'-MF}{2}.$

3. Since P is the pole of BC,

$$OM \cdot OP = R^2.$$

Substituting from (1) & (2)

$$\left(\frac{MF'-MF}{2}\right)\cdot\left(\frac{PF'+PF}{2}\right)=\left(\frac{PF'-PF}{2}\right)\cdot\left(\frac{MF+MF'}{2}\right).$$

Whence $PF \cdot MF' = MF \cdot PF'$ or

$$\frac{PF}{MF}=\frac{PF'}{MF'}$$

(b) To prove AG the (A) symmedian
1. Draw AF, AF' and AH through M.

$$AF' \text{ is } \perp AF.$$

Draw $KH \perp AF$ at F

then KH is parallel to AF'

2. $\triangle MAF$ is similar $\triangle MFH$: *a.a.a.*

$$\therefore \quad \frac{MF'}{MF}=\frac{AF'}{FH}.$$

3. Since KF is parallel AF', in $\triangle PAF$ and PKF,

$$\frac{PF'}{PF}=\frac{AF'}{KF}.$$

4. But by (a)

$$\frac{MF'}{MF}=\frac{PF'}{PF}.$$

Hence by (2), (3) & (4) $KF = FH$.
5. Also at $\triangle AFK = \text{at} \triangle AFH$.

$$\therefore \angle KAF = \angle HAF.$$

6. Since PF' is $\perp$bis. of side (chord) BC, AM is the (A) median. PF' also bisects are BC at F
$\therefore AF$ is the (A) bisector
Hence by (5) AG is symmetric of the median with respect to bisector A and is therefore by definition the (A) symmedian.

Note: *Altshiller-Court: College Geometry* (1925)

Pg. 226. ¶446: Theorem: "The symmedian issued from one vertex of a $\triangle$ passes through the point of intersection of the tangents to the circum circle at the other two vertices of the triangle"
Now these tangents intersect in P which is the pole of BC and (b) follows immediately.

2412. *Proposed by Bro. Felix John, Philadelphia.*

The sum of the numbers the sum of whose digits is ONE is 1. The sum of the numbers the sum of whose digits is TWO is 13(11+2). The sum of the numbers the sum of whose digits is THREE is 147(11+12+3). And so on. If possible, derive a formula for the sum of all these sums. That is, what does this equal?

$$S_n = 1+13+147+\cdots.$$

Solution by J. H. Means, Huston-Tillotson College

It is possible using finite differences and the advancing differences formula:

$$u_x = u_0 + x\Delta u_0 + \frac{x(x-1)}{2!}\Delta^2\mu_0 + \frac{x(x-1)(x-2)}{3!}\Delta^3\mu_0 + \cdots$$

where

$$u_0 = 1, \quad \Delta u_0 = 12, \quad \Delta^2 u_0 = 122, \quad \Delta^3 u_0 = 111.$$

We find the nth term of 1, 13, 147, $\cdots$ to be

$$\tfrac{1}{2}n(37n^2 - 100n + 65)$$

and the sum of n terms to be

$$S_n = n(n+1)(111n^2 - 289n + 190).$$

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2407, 9. *Lee Dresden Goldberg, Hillside, N.J.*

2407, 9. *John Hewett, Upper Canada College, Toronto.*

2407, 8, 9, 10. *Geoffrey Kandall, Far Rockaway, N. Y.*

2409. *Charles Clark, St. Louis, Mo.*

PROBLEMS FOR SOLUTION

2431. *Proposed by C. W. Trigg, Los Angeles City College.*

The bearing of a ship which is x nautical miles from a second ship is Sα°E. If the second ship travels due west at U knots, in what time will the first ship traveling at V knots ($V > U$) overtake her?

2432. *Proposed by C. W. Trigg, Los Angeles City College.*

A cube is divided into two parts by the plane of a hexagon whose vertices lie on the edges of the cube, and divide these edges in the ratio $x:(1-x)$. Show that (1) the surface area of the cube is divided into the same ratio as the lengths of the edges and portions of edges in the two parts, (2) the perimeter of the hexagon is independent of x.

2433. *Proposed by Richard H. Bates, Milford, N. J.*

If an isosceles trapezoid is circumscriptible, radius R, and also inscriptible radius r,

(1) Show that its area is

$$2r\sqrt{2r\sqrt{r^2+4R^2}-2r^2}.$$

(2) Show that its diagonal is

$$\sqrt{2r\sqrt{r^2+4R^2}+2r^2}.$$

2434. *Proposed by Norman Anning, Alhambra, Calif.*

Show that plane $x+y+z=0$ and the cylinder $x^2+xy+y^2=3$ have a circle in common: Find on this circle six points which have integral coordinates. What is interesting about them?

2435. *Proposed by Lester Moskowitz, Brooklyn.*

Use the integral,

$$\int \frac{dx}{x^3+x+1},$$

to evaluate to infinity the series:

$$\frac{1}{1.2}+\frac{1}{4.5}+\frac{1}{7.8}+\cdots.$$

2436. *Proposed by John Lowenthal, Exeter, N. H.*

In triangle ABC, AE is the altitude on BC, CD and BF meet AE at G. Prove that AE bisects angle DEF.

BOOKS AND PAMPHLETS RECEIVED

AN ANALYTICAL CALCULUS FOR SCHOOL AND UNIVERSITY, Volume III, by E. A. Maxwell, *Fellow of Queen's College, Cambridge*. Cloth. Pages vii+195. 13.5×21.5 cm. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $2.75.

EXERCISES IN WORKSHOP MATHEMATICS FOR YOUNG ENGINEERS, by Leslie Smith, *Lecturer in Mathematics at the Technical College, Derby, and Organizing Lecturer at the Works Training Schools, British Railways, Derby*. Cloth. Pages vi+90. 13×19 cm. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price 90 cents.

ALGEBRA: ITS BIG IDEAS AND BASIC SKILLS, Book II, by Daymond J. Aiken, *Head of Mathematics Department, Lockport Township High School Lockport, Illinois*, and Kenneth B. Henderson, *Professor of Mathematics Education, University of Illinois*. Cloth. Pages xii+397. 15×23 cm. 1954. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.96.

MATHEMATICAL PUZZLES AND PASTIMES, by Aaron Bakst, *Assistant Professor in the School of Commerce, Accounts and Finance and the Graduate School of Business Administration of New York University*. Cloth. Pages vi+206. 14×21.5 cm. 1954. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.75.

PERCEPTUALISTIC THEORY OF KNOWLEDGE, by Peter Fireman, Ph.D. Cloth. 50 pages. 14×21 cm. 1954. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $2.75.

TEEN-AGERS, by Gladys Gardner Jenkins, M.A., W. W. Bauer, M.D., and Helen S. Shacter, Ph.D. Cloth. 288+8 pages. 17.5×24.5 cm. 1954. Scott, Foresman and Company, 433 East Erie Street, Chicago 11, Ill. Price, $3.60.

ELEMENTARY METEOROLOGY, by George F. Taylor, Ph.D., Colonel, USAFR. Cloth. Pages viii+364. 14.5×23 cm. 1954. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.95.

THE GEOMETRY OF RENÉ DESCARTES. Translated from the French and Latin by Eugene Smith and Marcia L. Latham. Paper. Pages xiii+243. 13×20.5 cm. 1954. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.95 cloth, $1.50 paper.

ELEMENTS OF NUMBER THEORY, by I. M. Vinogradov. Translated from the Fifth Revised Edition by Saul Kravetz. Paper. Pages viii+277. 12.5×20.5 cm.

1954. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.00. cloth, $1.75. paper.

THE FERNS AND FERN ALLIES OF MINNESOTA, by Rolla M. Tryon, Jr. Paper. Pages xx+166. 14×21.5 cm. 1954. University of Minnestoa Press, Minneapolis 14, Minn. Price $4.00 cloth, $2.75 paper.

TEACHING RAPID AND SLOW LEARNERS IN HIGH SCHOOLS, by Arno Jewett and J. Dan Hull, Coordinators, and Others. Bulletin 1954, No. 5 Pages vi+97. 13.5×23 cm. Superintendent of Documents, U. S. Printing Office, Washington, D. C. Price 35 cents.

ELEMENTARY TEACHERS GUIDE TO FREE CURRICULUM MATERIALS, Edited by Patricia A. Horkheimer, A.B., *Staff Member, Educators Progress Service*; Paul T. Cody, M.A., *Staff Member, Educators Progress Service*; and John Guy Fowlkes, Ph.D., *Dean, School of Education, University of Wisconsin.* Eleventh Edition. Paper. Pages xiii+332. 19.5×27 cm. 1954. Educators Progress Service, Randolph Wis. Price $5.50.

BOOK REVIEWS

CURIOUS CREATURES, by Erna Pinner. Cloth. 256 pages. 14.0×20.3 cm. 1953. Philosophical Library, New York, N. Y. $4.75.

No need to remark that each circus has the side-shows as well as the "big tent." The book under review promises a parade and some performance of the freaks of the plant and animal world. It is not seeking to detract from the "big tent" but merely to realert the observer somewhat "fed-up" with the "better known."

Chapter captions program a menu of: Food freaks; Nesting novelties; Nursing fathers; Aquatic air-breathers; Cooperative nature; Egg origins; Feet for flying; Big birds (and others); Upside downers; Camouflage; "Moochers"; The fakers and Grounded aves.

The style is descriptive and prosaic with no use of the anecdotal to break the formal pedantic flow of the un-lilted though concise presentation. Judged from her over 100 drawings and the fidelity of her text to their interpretation one is lead to have faith in her competence to report. She claims to have observed many of the animals described.

For those who find an appeal in the oddities of our natural world this offering has possibilities. It bids for both botanists and zoologists. There are over 150 drawings most of them full paged. These are, almost all of them, made by the author. There is a three page double columned index for those who may wish to use the book for reference purposes.

B. CLIFFORD HENDRICKS
Longview, Wash.

CHEMISTRY FOR THE NEW AGE, Second Edition; by Robert H. Carleton, *Executive Secretary of the National Science Teachers Association;* Floyd F. Carpenter, *Principal of Stivers High School, Dayton, Ohio:* and R. W. Woline, *Instructor in Chemistry, Oak Park and River Forest High School, Oak Park, Illinois.* Cloth. Pages xiv+688. 13.5 by 22.5 cm. J. B. Lippincott Company, 227 South Sixth Street, Philadelphia, Pennsylvania. 1954.

This is a 1954 revised edition of a textbook which was first published in 1949. In their preface the authors give the following as their twofold purpose: "The first purpose is to contribute generously and effectively to the general education of all students. The second purpose is to help lay the foundation needed by some of the students for later specialization in science." A rapid survey of this text

convinces the reviewer that the above twofold purpose has been accomplished. Students using this text should obtain a good cultural background in chemistry and at the same time could be given an adequate foundation for further study of college chemistry. The extent to which the latter objective is attained will depend much upon the emphasis the teacher gives to certain subjects. For example, chemical arithmetic should be stressed at all times and the students should be provided with adequate laboratory experience.

The text is well organized into nine teaching units covering a total of fifty-eight chapters. The authors have used the scientific method in that experiments and scientific laws, in most cases, precede the theories. For example, concepts of chemical reactions were well emphasized and some of the laws of chemical combination were stated before Dalton's Atomic Theory was advanced. The subatomic theory of matter was not introduced until Chapter Seven when the student had had an opportunity to first clearly understand the atom as a unit.

In view of the Einstein relationship, $E=Mc^2$, the law of conservation of energy is poorly stated when the authors say "The total weight of all the substances entering into a chemical change *precisely equal* the total weight of all the substances produced by the change." If Einstein's formula means anything, the above cannot be true. It might better be stated: "The total weight of all the substances entering into a chemical change *appears to be equal* to the total weight of all the substances produced by the change." The authors seem to have the erroneous idea that it is only in some super reaction like an atom bomb explosion that matter ever disappears at the expense of energy formation. Even in what the authors choose to call "ordinary chemical changes" there may be a loss in weight, but the loss is so small that the average balances do not detect it.

The authors have provided for adequate problems, exercises, and reading references at the end of each unit. Problems are also found at the end of each chapter.

The publishing company has done an excellent job. The book is well bound and illustrations are very good. The print is easily read.

If any high school teacher of chemistry is considering a change in text, he should give consideration to *Chemistry for a New Age.*

GERALD OSBORN
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Kalamazoo, Mich.

MANPOWER RESOURCES IN MATHEMATICS: A Study Conducted Jointly by the *National Science Foundation and the United States Department of Labor Bureau of Labor Statistics*, by the National Science Foundation. 20×25 cm. Pages iv+22. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 1954. Price 20 cents.

This is a timely and useful report on personnel resources in the mathematics profession, based on data gathered in 1951 by the National Scientific Register. It gives the relative numbers of mathematicians and graduate students specializing in mathematics; their age, sex, citizenship status, military status, and educational background; the industries and types of work in which they were employed at the time the survey was made; and their yearly professional income. The findings concern approximately 1300 mathematicians with the Ph.D. degree and 700 other mathematicians holding mathematical positions. The facts are set forth in considerable detail in the form of tables and graphs. A few highlights may be of interest.

Teaching is the principal activity of the great majority of mathematicians, with research the chief function of the second largest number. Of the Ph.D.'s in the survey, 80 per cent were engaged primarily in teaching and 15 per cent in research. Another 4 per cent had administrative duties, and the remaining few were in consulting work or some phase of production. Of the group without Ph.D.'s, 71 per cent were employed in teaching and 19 per cent in research activities. Research workers in mathematics tend to be younger than members

of the profession who are employed in teaching. Among the teachers in the survey, the proportion under 35 years of age was only 27 per cent in the case of Ph.D.'s and 42 per cent for those with less academic training. The corresponding figures for mathematicians engaged primarily in research were nearly twice as great (47 per cent for Ph.D.'s and 80 per cent for others).

The income level of mathematicians with doctorates is markedly higher than that of masters and bachelors. The median annual professional income of the Ph.D.'s in the survey was $6,200 in mid-1951, while the group without doctorates had a median income of $4,400. Three-fourths of the Ph.D.'s had incomes of at least $5,000, while the top-paid fourth earned $7,900 or more. Among the mathematicians without the doctoral degree, three out of four earned at least $3,500, and one out of four, $5,400, or over. Mathematicians on the staffs of colleges and universities tended to have lower incomes than those in other types of employment, although they were an older group than the respondents employed in government and private industry. In contrast, the mathematicians in private industry had both the highest income levels and the lowest median age.

Women who hold professional positions in the field of mathematics are, with rare exceptions, employed by educational institutions (98% of the women Ph.D.'s, and 86% of the women with less advanced training). The concentration of personnel in teaching was greater in the case of women than with men.

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POWERS GOES TO CAIRO

Dr. Samuel R. Powers, Professor Emeritus of Natural Sciences at Teachers College, Columbia University, has been awarded a 1954–55 Fulbright grant to enable him to be a guest professor at the Abbassia Teacher Training College for Men in Cairo, Egypt.

In addition to teaching, Dr. Powers will assist in developing a curriculum for science teachers and serve as a faculty consultant in teacher education at the Egyptian college. He will also give general lectures at the Institute of Education in Cairo.

Before retiring in 1952, Dr. Powers was head of the Department of Teaching Science at Teachers College. He had been on the faculty of the college for twenty-nine years.

Dr. Powers was in charge of a national study of the teaching of natural Sciences, which was published as the Thirty-first Yearbook of the National Society for the Study of Education. From 1935 to 1944, he was administrative officer of the Bureau of Educational Research in Science.

INTERFERENCE MICROSCOPE MEASURES SMOOTHNESS

For measuring smoother surfaces, General Motors Research Laboratories is using an interference microscope, which detects depressions and ridges of two to 100 millionths of an inch.

One of three such instruments built in the United States, it determines extremely small depths by comparison with a beam of light from a flat reflecting surface.

The microscope is being applied to plating thickness, effects of weathering on painted surfaces, standardization of machine part surfaces, corrosion pitting and other such uses.

The best use of a journal is to print the largest practical amount of important truth, truth which tends to make mankind wiser, and thus happier.—Horace Greeley.